POWER

Volume 53 New York, April 19, 1921 *Number* 16

The Human Element

By BERTON BRALEY

You may talk for hour on hour of equipment and of power
And of all the wealth invested in the same;
And your system of transmission may be worth an exhibition,
And your turbines may be widely known to fame;
But they are not worth a jot if the labor that you've got
Either *will* not run them properly — or can't;
Though your modern installation may awaken admiration,
It's the men who give the value to your plant!

Motors, dynamos and boilers are but tools to aid the toilers,
They are genii responsive to command;
Though their might grows ever vaster, man is still their lord and master,
And it's men who carry out what you have planned.
Is there any greater blunder in the universe, I wonder,
Than to treat this human force with knowledge scant?
Do you see the thing I mean?—It is man above machine,
For it's men who give the value to your plant!

Though your every single shipment of mechanical equipment
Be the best and most efficient you can buy,
If the men who operate it do not prize, appreciate it,
Your returns will never mount exceeding high;
For your plant, or so I take it, is whatever men may make it,
So the problem's simply human, you will grant;
And the wise man pays attention to these matters that I mention,
For he knows that men give value to the plant!

Safety First Methods of a Big Power Plant

How the United Electric Light and Power Company of New York safeguards its operatives against accident, mechanical or electrical.

A CERTAIN ex-president of the National Electric Light Association has said that in the early days of electric lighting the way to start an electric-light plant was to "buy a barn, beg a belt, borrow a dynamo and steal an engine." With due regard for slight exaggeration and what a modern writer has termed "the pathos of distance," it does really seem as though some power stations, now happily a matter of history, were not only laid out but operated along the lines suggested. Although voltages and steam pressures were then comparatively low, the old-time chief or "engineer on watch," especially during a thunderstorm or in a sudden emergency call for "juice," was obliged to take long chances and keep his wits about him every minute, while even in the course of the ordinary day's work a misstep or careless movement was likely to spell disaster, if not worse. The fundamental "stop, look, listen" idea of our country grade crossings has been developed to a degree that apparently leaves little to be desired in modern power-plant operation, and an excellent example is to be found in the rules covering the employees of the United Electric Light and Power Company of New York City, in connection with the installation, operation and repair of steam, electrical and mechanical apparatus, which are reproduced herewith practically in full, with illustrations taken from photographs made at the Sherman Creek Station of that company.

All water-level glasses on steam boilers, other than prismatic water-level glasses, as well as gage glasses on tanks, standpipes or other storage receivers under pressure shall be protected by screens to prevent injury from flying glass in case of a glass bursting.

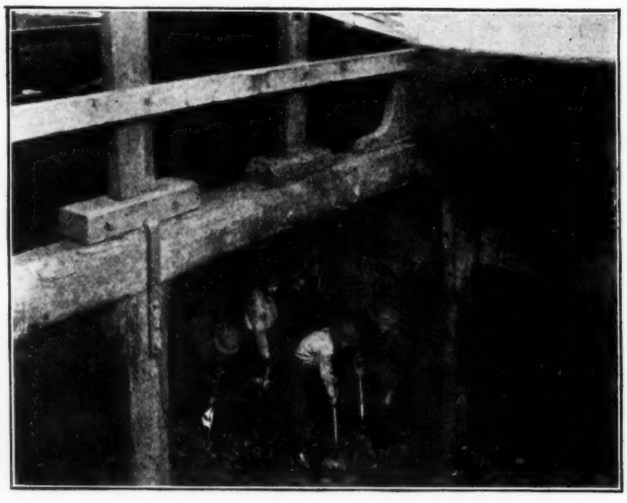


FIG. 1. STEEL HELMETS ARE WORN IN COAL BARGES AS A PROTECTION AGAINST FALLING COAL

Test cocks on water columns shall be fitted with extension rods or chains so as to be operative from the boiler-room floor level.

Tubes of all boilers in commission shall, so far as possible, be inspected once in 24 hours by a competent person, and should any blisters or defects be apparent the same shall be reported immediately to the engineer in charge of watch, who will at once take the boiler out of commission.

Before opening any steam, water or other valves on apparatus leading to a boiler that has been under repair the engineer in charge of the watch will assure himself that all employees are outside of the steam drum or body of boiler.

Boiler cleaners, when using turbine tube cleaner, must not turn on pressure until the turbine is inside of the tube, and in case it fails to work they will report the same to the foreman, and under no circumstances endeavor to try out the turbine outside of the tube.

Before renewing water-gage glasses on boilers under pressure close both combination cocks and open drain cock. After putting in the glass return to the floor and turn on steam slowly to warm up gage glass. If the stuffing boxes leak, before ascending a ladder to tighten the nuts, close the combination cocks and open the drain cocks. After tightening the nuts descend and arrange the valves for regular operation. All men are cautioned against crossing coal conveyors, ash conveyors or other moving apparatus, whether in use or not. All dampers shall be tagged with "not clear" signs while employees are at work on repairs to furnaces of boilers, and they shall be removed only on order of the engineer in charge of the watch. When work on boilers requires men to enter them, the engineer in charge of the watch will see that proper precautions are

taken to prevent injury to employees due to the opening of stop valves, plug cocks, check and feed valves.

No employee shall enter boiler drums, economizers, back connections, furnaces, ashpans or similar places unless ordered to do so by the engineer in charge of the watch or the foreman, who will see by his personal examination that these places are safe to enter.

When work is finished on a boiler and before starting to test the same, the foreman will see that all men, tools, waste and gear are out of the boiler.

Under no circumstances will the foreman permit men to enter the back or center connections of boilers or economizers while under any steam pressure or while the grates are under fire until he has personally inspected the same and is satisfied that there is no danger of the men being burned with hot soot or steam.

The foreman will close blowdown valves on boilers before permitting men to work on them, except when turbining tubes.

Turbines and Engines

All steam-turbine units shall be fitted with automatic self-closing valves.

All high-speed engines shall be fitted with automatic safety stops.

In stopping engines, turbines or other machinery the engineer in charge of the unit shall see that all precautions, such as opening drain valves, shutting cutout valves, etc., have been taken to prevent sudden starting of the unit by leakage of steam through the throttle valve.

After each run of generating units and other apparatus all parts of such units, circulating apparatus, etc., shall be examined to ascertain if all keys, pins, nuts, etc., are secure and safe and report made to the engineer in charge of the watch.

"Not clear" signs shall be attached to the throttle of engines, turbines, pumps and other machinery before employees are permitted to work on the same and the employee shall see that such "not clear" signs are removed only on the order of the engineer in charge of the watch.

No apparatus on which there is a "not clear" sign shall be started under any circumstances.

"Not clear" signs shall not be removed from any apparatus until the engineer in charge of the watch has assured himself that all men are clear of the apparatus.

No employee shall do any work on any machine or apparatus that may be started from the switchboard without first obtaining from the switchboard a "hold off" ticket.

Piping, Valves, Etc.

All stop valves on steam boilers shall be of the automatic self-closing type.

Outlets of all safety valves shall be vertical.

All large main cutout stop valves shall be provided with means whereby they may be closed from the boiler or engine-room floor or other remote point.

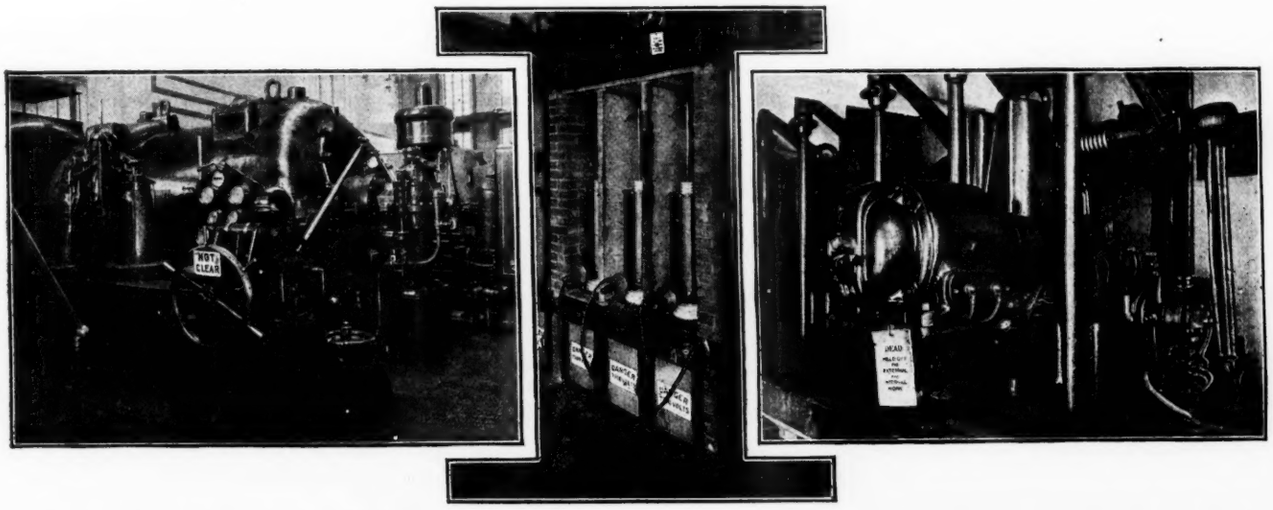


FIG. 2. (LEFT) TURBINE TAGGED "NOT CLEAR" DURING INSPECTION AND OVERHAULING; (CENTER) GROUND CLAMP ON HIGH-TENSION OIL SWITCH; (RIGHT) SWITCH-OPERATING MECHANISM MARKED "DEAD"

The engineer in charge of the watch shall give such instructions to other employees for draining piping and opening or closing valves, when cutting in a new steam heater or line of steam piping and in cutting out the same, so as to prevent the formation of "water hammer."

No valves on live-steam mains shall be opened or closed without an order from the engineer in charge of the watch *except in extreme emergency cases.*

All watch engineers and water tenders shall inform themselves of the layout of all piping, valves, cutout devices, and all safety-stop valves and appliances which are within their assigned stations and which they may be called upon to operate in an emergency should any accident occur.

The foreman of the repair crew, before beginning work on piping, valves, etc., shall ascertain from the engineer in charge of the watch that all such piping, etc., are free from steam and water and properly tagged with "not clear" signs.

While pressure is on the piping, economizers, boiler-tube caps or valves, no one shall tighten up or take up slack on the nuts or bolts of the same.

All parts of stokers moving at such speed as would make contact dangerous shall be so protected as to prevent accidental contact with such moving parts.

Gear-case covers completely inclosing the gears shall be fitted to all machine tools and be in place while such tools are being used.

Shafting running along or passing through floors shall be housed, screened or otherwise properly guarded.

Setscrews and keys in exposed positions on moving machinery and shafting shall be countersunk or otherwise properly protected.

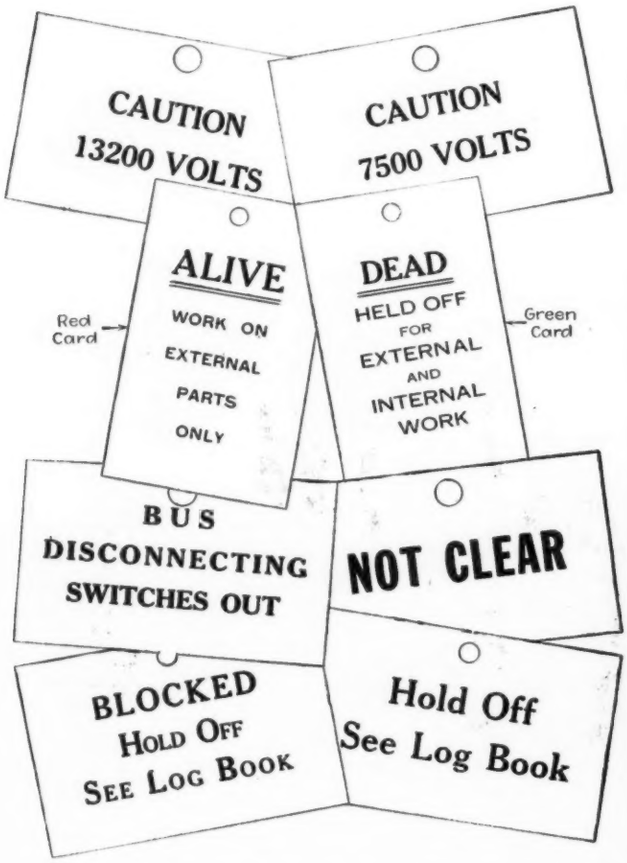


FIG. 3. PROTECTIVE TAGS USED IN DESIGNATING ANY APPARATUS NOT IN NORMAL OPERATING CONDITION

All belting shall be inclosed or otherwise protected wherever accidental contact is possible.

Circular saws and bandsaws shall be protected so as to guard as much as possible against accidental contact with saw blades.

The company will supply and maintain guard glasses for the uses of employees when working where chips or fragments are liable to strike the employees. Wire screens or tarpaulins either of a portable or permanent type shall be set up on workbenches or around employees engaged in chipping, to arrest chips and fragments.

Crane operators will not take orders from more than one person while engaged on a particular job.

Electric cranes in substations shall be used only by duly authorized employees.

Line and counter shafting must not be oiled while in motion except where permanent and safe provision is made for reaching such shafting.

When one man is working on top of a ladder the lower part of the ladder shall be secured from slipping by a man steadying the same, by fastening to permanent fixtures or by other approved methods.

Under no circumstances shall repairs be undertaken on any machinery while in motion.

All tools, chain falls, scaffolding for repair work, ladder, steam hose, tube cleaners and other equipment needed for operation or in repair service shall be inspected by the respective foremen, who shall report any defective apparatus.

Electrical Apparatus

Station foremen or operators in charge of switchboards will not allow anyone to come inside of high-tension inclosures or upon high-tension platforms unless accompanied by a regular employee of the electrical operating department, or by some employee of the construction or repair department who is authorized by a written permit from the high-tension operator to do certain work requiring his presence in the inclosure or on the platform.

All high-tension switch compartments shall, so far as their construction will permit, be so inclosed as to make it impossible, except when opening the compartments, for an employee to come in contact with electrically charged parts, either from the floor level or above.

All high-tension conductors in power stations or substations, when exposed and not adequately protected by insulation, shall be inclosed by screens or otherwise protected.

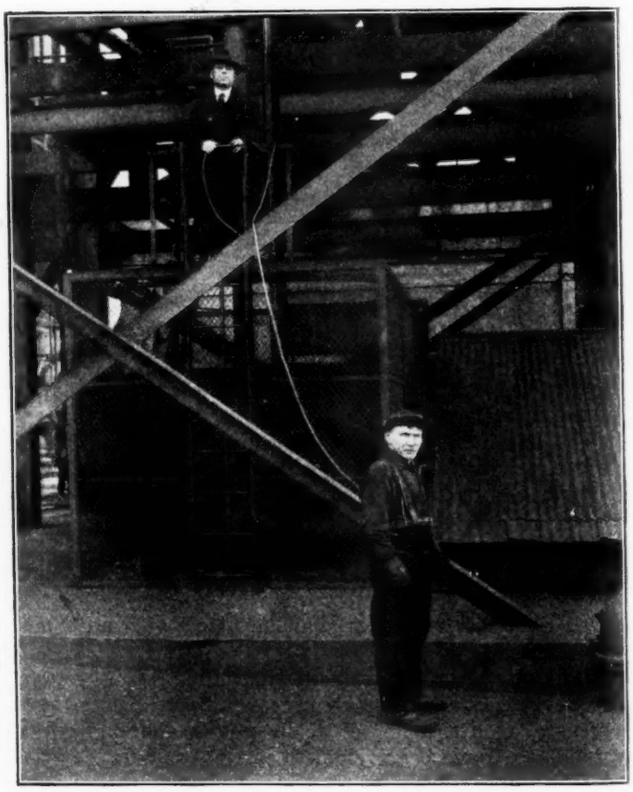


FIG. 4. SAFETY BELT FOR USE IN COAL BUNKERS

There shall be posted in conspicuous places in all power houses and substations diagrams describing and showing the connections of wires and cables (other than lighting and signal wires) and the switches, etc., controlling the same; and all such wires, cables and connections shall be so tagged and numbered that they may be readily identified.

All machines for the generation of current, or connected with such generation, shall be protected by rail-

ings so as to prevent employees coming in contact with moving or electrically charged parts.

There shall be at least two operators on duty in rotary transformer stations delivering current at 500 volts or higher when the same are in operation.

No employee (except linemen or properly qualified employees working on 2,500-volt circuits who must take all possible precautions to avoid danger) shall touch, either with or without rubber gloves, any switch, current or voltage transformer, busbar, cable, conductor or any other apparatus in use to carry current at a higher potential than 700 volts until he has positively ascertained that such conductor or apparatus is dead. Wherever possible 2,500-volt circuits shall be killed and grounded when tapping or splicing them.

When work is to be done on any distributing feeder, application must be made by a representative of the underground department to the substation operator, if possible, the day previous to doing the work. The distributing feeder to which the distributing mains are to be temporarily connected must be stated as well as the work to be done and the maximum time required.

Before the substation operator grants permission to work on a distributing feeder he will request the

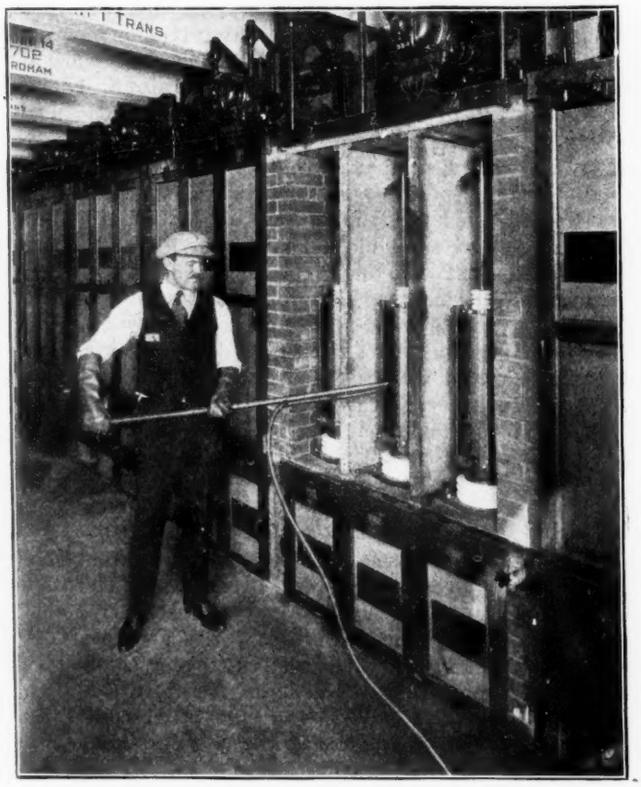
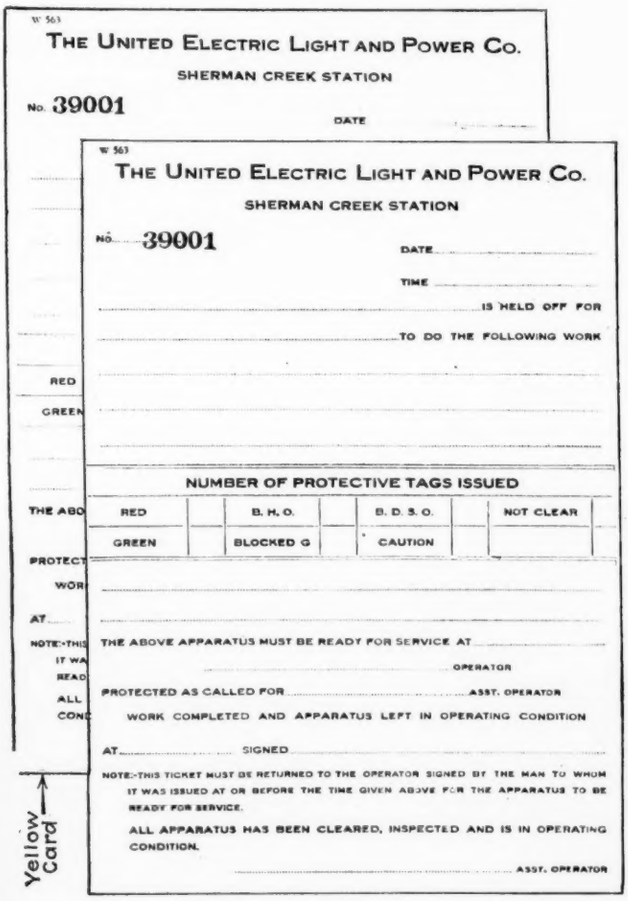


FIG. 5. THE "DISCHARGE STICK" IN USE

underground department representative to tie the distributing mains of the feeder to be "cut out" to the distributing feeder designated in request. When informed that feeders have been tied the operator will open feeder switch at substation, and if the feeder is found to be feeding back he will notify the underground department representative to open the distributing feeder switch. Upon receiving word that the distributing feeder switch has been opened the operator will have No. 1 and No. 2 bus switches blocked open, the knife switches opened on each side of the oil switch and the feeder grounded and short-circuited. "Not clear, off for underground department" card must be placed on switches and their control. The feeder must not be again placed in service until reported as clear



W 563

THE UNITED ELECTRIC LIGHT AND POWER CO.

SHERMAN CREEK STATION

No. 39001

DATE

W 563

THE UNITED ELECTRIC LIGHT AND POWER CO.

SHERMAN CREEK STATION

No. 39001

DATE

TIME

IS HELD OFF FOR

TO DO THE FOLLOWING WORK

RED

GREEN

NUMBER OF PROTECTIVE TAGS ISSUED

RED		B. H. O.		B. D. S. O.		NOT CLEAR	
GREEN		BLOCKED G		CAUTION			

THE ABO

PROTECT

WOR

AT

NOTE-THIS

IT WA

READ

ALL

CONC

THE ABOVE APPARATUS MUST BE READY FOR SERVICE AT

OPERATOR

PROTECTED AS CALLED FOR ASST. OPERATOR

WORK COMPLETED AND APPARATUS LEFT IN OPERATING CONDITION

AT SIGNED

NOTE:-THIS TICKET MUST BE RETURNED TO THE OPERATOR SIGNED BY THE MAN TO WHOM IT WAS ISSUED AT OR BEFORE THE TIME GIVEN ABOVE FOR THE APPARATUS TO BE READY FOR SERVICE.

ALL APPARATUS HAS BEEN CLEARED, INSPECTED AND IS IN OPERATING CONDITION.

ASST. OPERATOR

Yellow Card

FIG. 6. AUTHORITY AND CLEARING SLIPS PLACE THE RESPONSIBILITY FOR APPLICATION AND REMOVAL OF ALL TAGS

by the representative of the underground department or until it is positively known that all workmen are clear from the feeder.

No employee shall work on 2,500-volt circuits without wearing rubber gloves, which will be furnished, regularly tested and kept in good repair by the company.

When work is to be done on any transmission feeder, under the control of the system operator, application must be made by a representative of the underground department to the system operator, if possible the day previous to doing the work, upon a prescribed form, stating fully the work he intends to do and the maximum time necessary for completion, with a rough sketch showing any changes in connections, routes or numbers. Permission must be obtained from the system operator for killing the feeder, and the work must not be started until the foreman in charge of the work or his representative has been informed by the system operator that the feeder has been killed and grounded and tags placed on the switches at each of the feeders and on the control switches for the same.

Before the system operator grants permission to work on a transmission feeder he will arrange with the station or substation affected to have the feeder

killed, the switches at each end blocked open, and the feeder grounded and short-circuited. He will also instruct the operators to tag the switches and their control with tags provided for this purpose. The feeder must not be again placed in service until released by the foreman or his representative or until it is positively known that all workmen are clear from the feeder. The system operator will also make suitable indication on his indicator board that the feeder is out of service.

No foreman or repair man shall work on any feeder or high-tension apparatus until he has received his individual permit, and under no circumstances will a foreman or repair man work on another man's permit.

As soon as the system operator receives information from the power station or substation that a transmission feeder has been grounded and short-circuited, and the necessary tags have been placed, he will release the feeder to the foreman and at the same time inform him of the places where grounding connections have been made.

Dead Tests Before Beginning Work

After being informed by the system operator that a transmission feeder (or by the substation operator that a distributing feeder) is dead or grounded the man in charge of the work, before starting work on such feeder, will test to ascertain if it is dead, as follows: He will first use the coil and telephone receiver provided for the purpose. If this indicates that the feeder is not carrying current he will strip off the lead of a short piece of the cable, using rubber gloves, and then with a saw whose blade is grounded to a suitable ground will carefully cut into the cable. If there is any indication that the feeder is alive he will communicate with the system operator or substation operator at once.

Upon the completion of the work on the transmission feeder the foreman or his representative will have the feeder cleared and notify the system operator that the work is complete. Before releasing the feeder he must have positive knowledge that the workmen understand that the feeder is to be made alive. The system operator will then order off the short-circuiting and grounding connections, have the tags removed, and have the necessary tests made.

If the work has been such that there is a possibility of the connections being changed a phase test must be made before any feeder is put in service.

A permanent record of the taking out and returning to service of all feeders must be kept in the station log.

If a third rail is to be killed all control switches by which current may be thrown to any section of it shall be tagged by the substation operator. The foreman in charge of the work shall inform the substation operator when the work is completed.

When instructions are received from the system operator to ground a feeder the operator shall first ascertain if the switches controlling the feeder are blocked open. He will then test with the ground stick to determine if the feeder is dead, and then ground with leads, provided for the purpose, which shall be first attached to the ground, the other end then being attached (one lead at a time) to each leg of the feeder, making certain that all clamps are securely fastened. The grounding leads shall never be removed from the circuit until the work has been completed and instructions received from the system operator.

When the work is to be done on any apparatus or cable in connection with the transmission system under the control of the system operator, in the station or substation, notice shall first be given to the system operator as to the character of the work and the time required for its completion. If any alterations are to be made in the connection or location of any of the apparatus, or any addition made thereto, full information with a sketch shall be furnished the system operator by the department desiring to make the alterations or addition at least 24 hours, if possible, before starting the work. In case of repair work where no alteration is to be made in the connection or location of high-tension apparatus no sketch will be required. Station foremen or operators in charge of stations will not allow work to be started on the high-tension system or auxiliary apparatus connected thereto without first having notified the system operator.

Before starting work on any apparatus in connection with the transmission system the foreman in charge of the work or his representative shall ascertain from the operator at the station in which the work is to be done that the cable, switch, bus, or connection on which he desires to work is dead; that is, that it is not connected either directly or through primaries of voltage transformer with any source of high potential in any station, and that it has been discharged to ground since last having carried high-tension current.

Before permitting a foreman in charge of work or his representative to begin work the operator in charge of the station in which the work is to be done shall notify the system operator that the man is ready to begin the work described in the notice previously given to the system operator. Upon word from the system operator authorizing the work the station operator or his assistant shall block switches, with blocks provided for the purpose, discharge all conductors with the discharging device provided for the purpose, connect all conductors to ground and to each other by means of the grounding and short-circuiting device provided for the purpose, and place a "not clear" card on the apparatus. In applying the grounding and short-circuiting device, it should be first attached to the ground and then one leg at a time should be attached to the conductors.

Responsibility Centered on Foreman

In doing this work the operator or his assistant shall wear rubber gloves and exercise great care. The foreman in charge of the work or his representative shall personally inspect the blocking of the switches, discharging, grounding and short-circuiting of conductors, and posting of "not clear" cards on the apparatus upon which he is to work. When the man in charge of the work reports the work finished the operator shall note the same in the high-tension logbook, and if personal inspection shows that the apparatus held off is then ready for service he shall notify the system operator, and on instructions from him remove the grounding and short-circuiting device, switch-blocks, and "not clear" cards. After having done so he shall immediately record it in the logbook.

When an insulation test is to be made or work done on high-tension cables in the subway the system operator shall instruct the substation operator as to the blocking and grounding of switches and the posting of "not clear" cards. The substation operator shall record all such work in the logbook. If the cable is to be tested

from the substation end the tester shall personally inspect the discharging of the cable.

When it may be necessary for the meter and test department to make tests on high-tension apparatus in any station it shall arrange with the operating department for such test and for the "holding off" and protection of the apparatus upon which it is to work in accordance with the foregoing rules, and if the test necessitates changes in high-tension connections they shall be arranged for by the operating department. When the meter and test department shall have completed the test, it shall so report to the operating department.

In making phase tests or other special tests where it may be necessary to have the conductors or apparatus alive the man shall wear rubber gloves, use the devices provided for the purpose, and exercise greatest care.

Whenever the "holding off" or "clearing" of apparatus which has been "held off" requires the removal or replacing of voltage transformer fuses, the opening or closing of voltage transformer or bus switches, the removal of oil-switch doors, transformer doors or bus doors, the grounding of apparatus or the removal of grounds, or requires the exposure of any conductor which carries or may carry high-tension current, the operator doing such "holding off" or "clearing" of apparatus shall be accompanied by another electrical employee, who shall check all work done by the operator, and such work must be done only on a written order from the high-tension operator. Two men, one acting as a check on the other, will make phase tests, breakdown tests, continuity tests and all other tests on high-tension apparatus.

The operator shall immediately report to the system operator any fault that develops in any part of the transmission or the transformation system, or any incident which in any way affects the service or necessitates taking any of the generating, transmitting or transforming apparatus out of service for testing or repairs.

Note: The foregoing rules applying to feeders, cables and apparatus under the control of the system operator also apply to feeders, cables and apparatus not under the control of the system operator, except that in the latter cases the high-tension operator at the generating station acts as the system operator.

Safety apparatus such as speed-limiting devices, reverse-current and overload relays on station and substation apparatus, must be tested at frequent intervals.

General Instructions

Elevator wells shall be properly and substantially inclosed, secured or guarded, and in case of freight elevators shall be provided with proper traps and automatic doors in or at all elevator ways so as to furnish substantial covering when closed and to open and close by action of the elevator in its passage either ascending or descending.

All stairways around operating machinery or boilers shall be provided with safety treads and kept free from oil and water and shall be properly protected with handrails.

A sufficient number of pails of clean, dry sand shall be kept in all power stations, substations, auxiliary and switching stations.

Power stations, substations, auxiliary and switching stations shall be provided with a sufficient number of chemical fire extinguishers, of such type that the contents cannot act as an electrical conductor. No other extinguishers shall be kept at the stations unless conspicuously labeled that they are not to be used until current has been shut off.

All power stations, substations, auxiliary and switching stations shall be provided with a first aid or emergency kit.

All power stations and substations shall be provided with a pulmotor which shall be maintained in condition for immediate use.

In hoisting material warning signs and a man on guard shall be placed below, where such space is liable to be used as a passageway.

All shafts, elevator wells or other openings over passageways shall have warning signs below and wire-mesh nets or tarpaulins spread in the same as far as practicable to catch any falling material when any employee is working in the upper part.

All openings such as elevator wells, holes in flooring, etc., shall be roped off or protected by railings when left unguarded, and in addition a red light (lantern or electric) shall be hung in the immediate vicinity when the location is unlighted or poorly lighted.

A Comparative Evaporation Test

An interesting test was recently made by Gilbert & Ashfield, engineers, at the plant of Wallace & Co., Brooklyn, N. Y., to determine the comparative results of coal and oil burning under a 72-in. diameter, 18-ft. long horizontal return-tubular boiler.

The boiler was the only one in use at the time, and the steam was drawn as needed for candy cooking and for operating the generating plant without regard to test conditions, except that usually two boilers were fired. The same boiler, set 24 in. above the grates, was used in both the coal and oil tests at an average pressure of 95 pounds.

Coal Test Run on Feb. 17, 1921

From 8 a.m. to 2 p.m. the coal used was a hand mixture of three parts No. 3 buckwheat and one part bituminous, very unevenly mixed. This is the usual fuel at this plant. From 2 p.m. to 5 p.m. bituminous coal only was used. Forced ashpit draft was maintained with a blower in both cases. At 7:55 a.m. the water was marked by a string on the glass, and the blowoff and all other drips were observed to be tightly closed.

Results obtained 7:55 a.m. to 2 p.m. gave an equivalent evaporation from and at 212 deg. F. of 6.75 lb. of water per pound of mixed coal and an equivalent evaporation of 8.33 lb. of water per pound of combustible.

The fire was cleaned at 2 p.m., the water standing at the mark on the glass, and straight bituminous coal was then fired.

Results obtained, 2 p.m. to 5 p.m. gave an actual evaporation of 6.93 lb. of water per pound of coal as fired or an equivalent evaporation from and at 212 deg. F. of 7.3 lb. of water per pound of bituminous coal.

Oil Test Run on Feb. 24, 1921

The boiler was equipped with three oil burners of the five-tip type during the week following the coal test. The grates were left in place, covered with ashes, and combustion blocks were set on them for the oil flame to impinge against. The burners were supplied with oil by suction of the atomizing steam from a heater barrel, there being no oil pressure or gravity feed on the burner.

Two barrels were placed in the boiler room, one above arranged to drain into the other below. The lower barrel had a steam coil which heated the oil to 118 deg. F. The oil, total quantity 610 gal., was delivered in thirteen barrels and was of 18 to 20 Baumé gravity. Each barrel was drained in the yard above the boiler room into a pan connected to the receiving barrels below by means of a 3-in. galvanized sheet-metal pipe placed in the coal chute. One-half barrel of oil was used on the afternoon preceding the test to try out the equipment.

At 5:30 a.m. there was 20 lb. of steam on the other boiler with a banked coal fire. With this low pressure and a deal-cold boiler, it required 2½ bbl. of oil to raise steam to 100 lb. pressure by 7 a.m. and carry it to 8 a.m. when the test started. This left a balance of ten barrels of oil for the test run.

Results obtained, 8 a.m. to 2 p.m. gave an actual evaporation of 117.1 lb. of water per gallon of oil, or 14.8 lb. of water per pound of oil, and an equivalent evaporation from and at 212 deg. F. of 122.7 lb. of water per gallon of oil.

Comparison of this result with mixed coal of 6.75 lb. of water per pound of coal ($6.75 \times 2{,}000 = 13{,}500$ lb. of water per ton of coal) gives 110 gal. of oil per ton of coal on a corrected basis.

These comparative quantities are on as fair a basis as could be arranged. The identical boiler was used, the load was practically the same, the actual water evaporation being 41,375 lb. for the coal and 42,768 lb. for the oil. These figures are very close, as are the same figures corrected from and at 212 deg. F., namely, 44,009 lb. for the coal, and 44,804 lb. for the oil.

The comparative result of 110 gal. of oil per ton of mixed coal is very conservative because the oil burners were installed in a temporary manner and lacked the features included in the permanent equipment, of superheating the atomizing stem, air-mixing control and sufficient preheating of the oil from which better results may be expected.

Oil Test Continued

The oil test was continued beyond 2 p.m. until 4:15 p.m., when practically all the oil was consumed. The actual water evaporated during this period was 37 bbl. of 14,356 lb. net weight at 200 deg. F., the oil used amounting to 106.5 gallons. The equivalent evaporation from and at 212 deg. F. was $14{,}356 \times 1.03 = 14{,}787$ lb. of water.

Adding these figures to those obtained between 8 a.m. and 2 p.m. gave an equivalent evaporation of 126.4 lb. of water per gallon of oil.

Making a comparison of this result with that for mixed coal ($2{,}000 \times 6.75 = 13{,}500$ lb. of water per ton of coal) gives 106.8 gal. of oil per ton of mixed coal.

[Recent current prices for coal and oil, New York delivery, as used in this test, were $6.82 per ton and $0.06 per gallon respectively.—Editor.]

A central station with an ultimate capacity of 250,000 kw. is being considered in England. The scheme has been proposed by a conference of the electricity authorities of the Mersey and West Lancashire Districts. For the present only four installations of 25,000 kw. capacity each are planned, although it is intended that eventually there shall be ten sets. The estimated cost of the first four sets and the transmission equipment is, at the normal rate of exchange, about $22,000,000.

Cause of Boiler Explosion

By Arthur L. H. Street

The old-time and unsolved question as to who committed the assault upon William Patterson often finds a parallel for mystery in what caused the explosion of a steam boiler. And sometimes all the inquisitorial powers of a court fail to ascertain definitely the cause. So it happened in the case of the Banner Laundry Co. vs. Great Eastern Casualty Co., 180 Northwestern Reporter, 997.

As an incident to reviewing a question as to whether the explosion of a steam boiler in the plaintiff's laundry in St. Paul resulted from a cause within the control of the plaintiff, so as to preclude the laundry company from recovering on an insurance policy for the breakage of plate glass in the explosion, the Minnesota Supreme Court says:

It is not clear that negligence will be presumed from the fact that a steam boiler exploded. There is such a presumption in the case of steamboat boilers, but that is because of a Federal statute. . . . The courts are at variance as to the application of the doctrine of *res ipso loquitor* [rule that negligence is presumed from the occurrence of an accident] to ordinary boiler explosions. The majority rule is that it does not apply.

The plaintiff's engineer had been in charge of the boiler for about eight years. It was inspected regularly and found to be in good condition. The safety valve was tested daily. It was set at 110 lb. and blew off at that pressure when tested at 2:20 p.m. on the day of the explosion. Work at the laundry stopped at 5 p.m. At that time there was practically no fire in the firebox—"just a couple of shovelfuls of coal." The engineer left at about 5:10 p.m. Fifteen minutes later the explosion occurred. When he left, the water was over the top flues and the steam gage registered a pressure of 75 or 80 pounds. He always left the boiler in substantially the same way at the end of his day's work.

The defendant's witnesses, who examined the boiler after the explosion, testified that it burst because the stem of the safety valve was bent so the valve stuck and would not permit the escape of the steam made after the engineer left, and that the pressure must have run up to more than 533 pounds, owing to the fact that the heat was confined by the firebrick incasing the boiler. It was the theory of some of the expert witnesses that water had combined with steam when the valve blew off, and that the rush of water and steam were like hammer blows on the seat of the valve and were so violent as to bend the stem. According to the experts this may happen at any time, and there is no way of guarding against it.

The testimony thus far referred to indicates no negligence on the part of the plaintiff. The defendant contends that the testimony of its expert witness was such as to require the submission of the issue of negligence to the jury. He testified that it was not safe practice for an engineer to leave a boiler until an hour after shutting down, but it would be safe to do what the engineer did on this occasion if the safety valve was working properly. He accounted for its failure to work on the theory that it might have been tied down. The trouble with all the theories as to what caused the valve to stick is that they have no foundation in the evidence. The most that can be said is that the evidence showed that the valve stuck for some unknown reason. It never had happened before, although the boiler had been left under the same conditions for years. Something unusual and extraordinary must have happened. The plaintiff was bound to anticipate and guard against that which usually happens or is likely to happen, but not against that which was only remotely or slightly probable. . . .

Irrespective of the question of the burden of proof and from a consideration of all the evidence, we think it is reasonably clear that the explosion did not occur through any negligent act or omission of the plaintiff, but from some unknown cause he could not anticipate, and which was beyond his control.

Modern Hydraulic Turbines—Features of Design*

Factors That Influence Location of Runner Above Tailwater—Specific Speed for High-Head and Low-Head Wheels—Water-Friction and Leakage Losses—Effects of Draft-Tube Design on Turbine Efficiency

By FRANK H. ROGERS
Hydraulic Engineer, I. P. Morris Department, William Cramp & Sons Ship and Engine Building Company

THE hydraulic design of the water passages on the pressure side of the turbine is based on the total effective head; that is, the velocities, expressed as head, used in the casing, through the speed-ring vanes, guide vanes and runner vanes, are based on the total effective head. As the losses that occur from friction and eddies in these water passages are also proportional to the velocity heads used, it is evident that the performance of a turbine under any head can be accurately calculated from the results of tests made on the model at a very much lower head. Thus, having tested a given turbine at a definite head, if this same machine is operated under a higher head the speed of the unit will vary as the square root of the ratio of the heads, the quantity of water flowing as the square root of the ratio of the heads, and the horsepower developed as the three-halves power of the ratio of the heads.

Fig. 1 shows a sectional plan view through a volute casing and indicates the relative positions of the speed-ring vanes, guide vanes and the runner vanes. In determining the velocities to be used through these parts it is usual to assume a velocity head at the entrance to the volute casing of about 3 per cent of the total effective head. As the water passes around the volute casing it assumes the shape of a "revolving

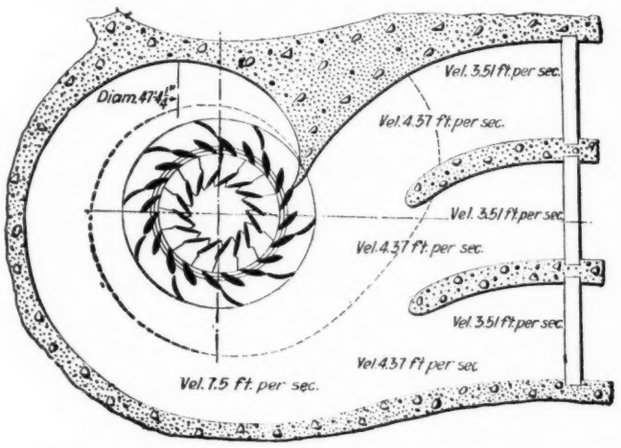

Diam. 47¼"
Vel. 3.51 ft. per sec.
Vel. 4.37 ft. per sec.
Vel. 3.51 ft. per sec.
Vel. 4.37 ft. per sec.
Vel. 3.51 ft. per sec.
Vel. 4.37 ft. per sec.
Vel. 7.5 ft. per sec.

FIG. 1. SECTIONAL PLAN VIEW THROUGH VOLUTE CASING, SPEED-RING VANES, GUIDE VANES AND RUNNER VANES

vortex" having its center at the center line of the shaft. The modern conception of the flow throughout a hydraulic turbine is based on this revolving vortex and that the velocity at any point times the radius to the center of the vortex is a constant. For this reason in a volute casing the average velocity increases around the volute as the water is approaching closer to the center of revolution. Until recently it was considered best in designing such volute casings to allow a decrease in velocity as the water passes around the volute, due to the fact that friction loss increases as the conduit decreases in size. Therefore in these designs it was attempted to decrease the velocity as the water passed around the volute casing. However, as just

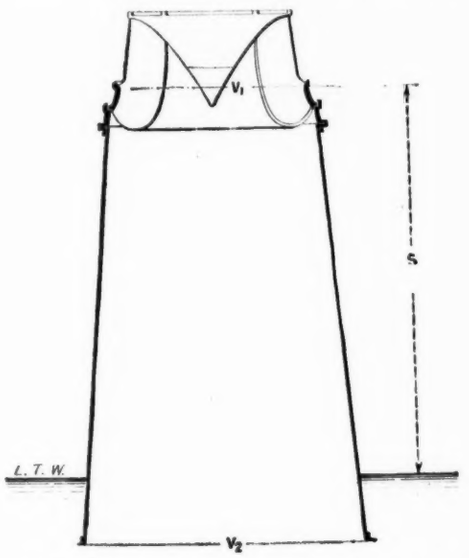


FIG. 2. SHOWS FACTORS THAT MUST BE CONSIDERED WHEN DETERMINING TOTAL DRAFT HEAD

pointed out, in actual practice the velocity increases, and if the sections of the volute are made too large eddies and whirls result, causing considerable loss in head.

The speed-ring vanes only act as stay vanes for the casing and therefore are laid out to correspond with the flow lines and thus cause a minimum of obstruction. The guide vanes are designed to line up with the speed-ring vanes at the point of best efficiency, and it is important in order to avoid losses that the guide vanes be designed for contraction of the stream at all points up to the runner entrance.

On the discharge side of the turbine the velocities used cannot be based on the total effective head, but as pressures below the atmosphere are being dealt with the limiting feature is absolute-zero pressure. Therefore a careful investigation must be made for each particular design of runner and its location above the tailwater, so that the total vacuum at the top of the draft tube will never exceed the barometric column. Fig. 2 gives the factors that must be considered. The total vacuum at the throat of the runner is dependent

*Paper presented at a joint meeting of the Engineers Club of Philadelphia and the Philadelphia sections of the American Society of Civil Engineers, American Institute of Electrical Engineers and American Society of Mechanical Engineers. First part of paper appeared in the April 12 issue.

not only on the static elevation above tail-water elevation, but also on the velocity head existing at this point. At sea level and a temperature of about 70 deg. F. the barometric column is about 33 ft., and for such conditions the total draft head, as determined by the formula $S + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} - Losses$ (see Fig. 2) should not exceed about 27 ft., since a certain margin must be maintained between these two values to allow for the pressure changes due to the movement of the

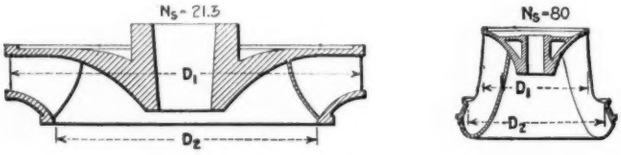


FIG. 3. HIGH- AND LOW-SPEED FRANCIS RUNNERS

turbine gates for regulating purposes. For plants located at elevations above sea level, where the barometric column is less, the same margin should be allowed in determining draft head.

Special Features of Design

The relative importance of certain features of the design of the turbine depends upon the speed characteristic of the runner chosen. For low heads high specific speeds are used whereas for high heads low specific speeds must be used. Fig. 3 shows typical high- and low-speed Francis runners which under the same head

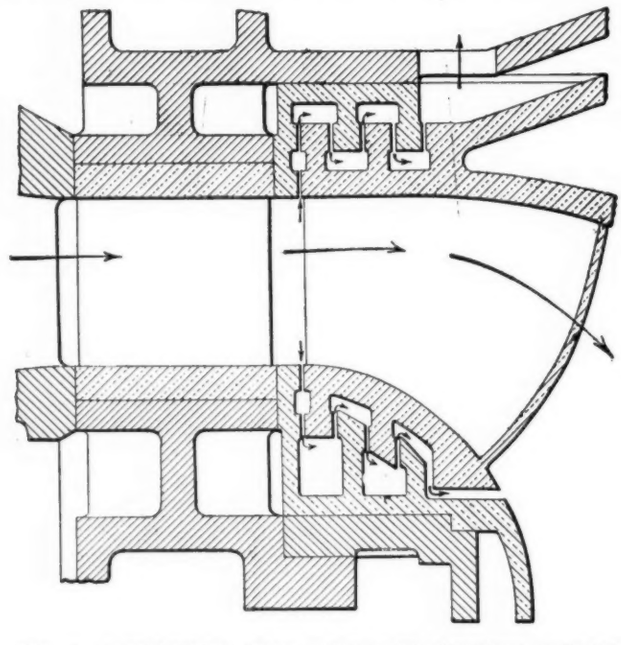


FIG. 4. LABYRINTH SEAL RING FOR 30,000-HP. RUNNER TO OPERATE UNDER 680-FT. HEAD

would develop the same power, but at speeds of revolution directly proportional to their respective specific speeds.

The runner shown to the left in the figure would be suitable for heads from 600 to 700 ft. and the runner to the right for heads from 15 to 40 ft. It would seem desirable for economic reasons to use the high-speed type runner for all heads, but owing to its small size, if used under a high head, the velocities would be excessive, resulting in the following conditions: (a) The whirls and eddies, although proportional to the head, would actually be of great magnitude, and owing to the more radical curvatures the life of the runner would be endangered because of mechanical wear and

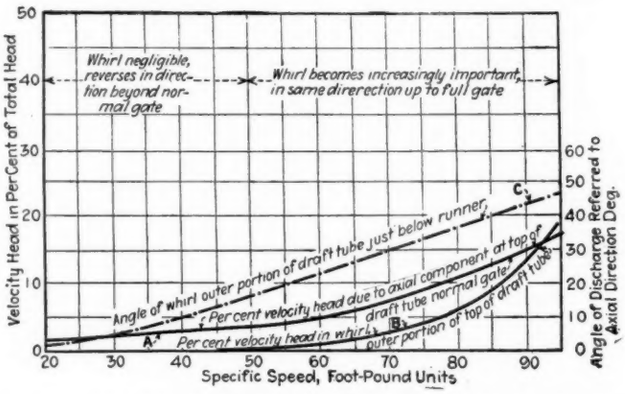

Velocity Head in Per Cent of Total Head
Whirl negligible, reverses in direction beyond normal gate
Whirl becomes increasingly important in same direction up to full gate
Angle of whirl outer portion of draft tube just below runner
Per cent velocity head due to axial component at top of draft tube normal gate
Per cent velocity head in whirl, outer portion of top of draft tube
Angle of Discharge Referred to Axial Direction Deg.
Specific Speed, Foot-Pound Units

FIG. 5. VELOCITY HEADS AT TOP OF DRAFT TUBE FOR VARIOUS SPECIFIC SPEEDS

pitting; (b) the high-velocity head at the throat of the runner (D_2) would cause excessive draft head.

This latter condition can be better appreciated by concrete examples. Thus a runner of this specific speed (80), having a diameter D_2 of 5 ft. and operating under a head of 30 ft., would run at 132 r.p.m. and develop about 1,800 hp. At this load the actual velocity through the throat of the runner D_2 would be about 27 ft. per sec., equivalent to a velocity head of 11.3 ft. Subtracting the losses in the tube and the outflow loss at the discharge of the tube would leave 7.5 ft. as regained velocity head, which must be added to the height of the runner above tailwater to obtain the total draft head. In the case assumed the runner could be located 17 or 18 ft. above tailwater. If the head were increased to 60 ft. this runner would develop 5,100 hp. and the corresponding regained velocity head would be 15 ft., so that the runner should be located not more than 9 or 10 ft. above tailwater. It is thus seen that as the head on the runner is increased the position of the runner with respect to the tailwater elevation must be lowered.

If, as an extreme case, the head were increased to 600 ft. the runner would develop about 160,000 hp. and the throat velocity would increase to 120 ft. per sec. (equivalent velocity head 224 ft.), giving a regained velocity head of about 150 ft., which would require the ridiculous condition of locating the runner 125 ft. below tailwater.

For a head of 600 ft. the low-speed runner shown (specific speed 21.3), with a runner diameter D, of 5 ft., would run at 525 r.p.m. and develop 14,500 hp. The throat velocity would be about 26 ft. per sec. (equivalent velocity head 10.5 ft.) and the regained velocity head about 7 ft., so that for this runner a height above tailwater of 18 ft. would be permissible. Hence it is seen that the head determines the specific speed that can be used.

For high heads the runner diameter is relatively large, so that disc friction and leakage are factors to consider in the design. The former loss is the power required to drive the runner submerged. It has been found by experiment that the water above and below

the runner rotates at about half the speed of the runner, and hence a friction loss occurs between this water and the stationary parts (the upper and lower covers), and an additional friction loss occurs between this water and the runner. To keep this loss as low as possible the inner surfaces of the covers and the outer surfaces of the runner must be made smooth and free from unnecessary projections.

It may be proved theoretically that the loss due to revolving a flat disc in water is proportional to the fifth power of the diameter and the third power of the speed. Hence a formula for disc loss may be written as follows:

$$HP = KD^5N^3.$$

where HP is the horsepower loss, D is the runner diameter in feet, N is the revolutions per minute, and K is the coefficient depending on character of surfaces.

Experiments that have been made on machined brass disks give a value of $K = 0.000000000413$. No tests have been made on turbine runners to determine this loss, but for comparative purposes the same coefficient may be used.

As an example we will consider a turbine now under construction for the Big Creek No. 8 Development of the Southern California Edison Co. This turbine is designed for 30,000 hp. under a head of 680 ft. at a speed of 428 r.p.m., the specific speed being 21.3 and the runner diameter 6.55 ft. The disc-friction loss as given by the foregoing formula equals 389 hp., or 1.3 per cent of the full-load output. As this disc loss is constant for all gates it would amount to 2.6 per cent at half load.

On the other hand, as an example of the disc-friction loss on a low-head turbine, if we consider a 10,000-hp. machine designed for a head of 30 ft. and having a specific speed of 80, the turbine would run at 56 r.p.m., the runner dimensions being 11.8 ft. for D_1 and 15.2 ft. for D_2, giving an average diameter of 13.5 ft. For this runner the disc-friction loss as given by the foregoing formula would be 32.5 hp., or only about 0.3 per cent of the full-load output. Therefore in the case of high-head units this loss is of considerable importance, especially at part loads, and must be taken into account in calculating the possible efficiencies to be expected.

The second loss mentioned, leakage at the runner seals, is also an important factor in the design of high-head units. This leakage water escapes between the periphery of the runner and the stationary parts and hence performs no useful work. The amount of this leakage depends on the pressure existing at the intake to the runner and on the area between the runner seals and stationary parts.

As a comparison of this leakage loss between high- and low-head turbines consider the 30,000-hp. wheel under 680-ft. head. If for this runner the usual type of single straight seal were used the leakage at the seals would amount to approximately 12 cu.ft. per sec., which is 2.6 per cent of the full-load quantity required by the unit, whereas for the 10,000-hp. unit under the 30-ft. head, the leakage loss will also amount to approximately 12 cu.ft. per sec., which, however, in this case is only 0.35 per cent of the full-load quantity. This loss, therefore, is of importance on high-head units, and special provision must be taken to reduce it to a minimum. This is accomplished by furnishing labyrinth seal rings as shown in Fig. 4.

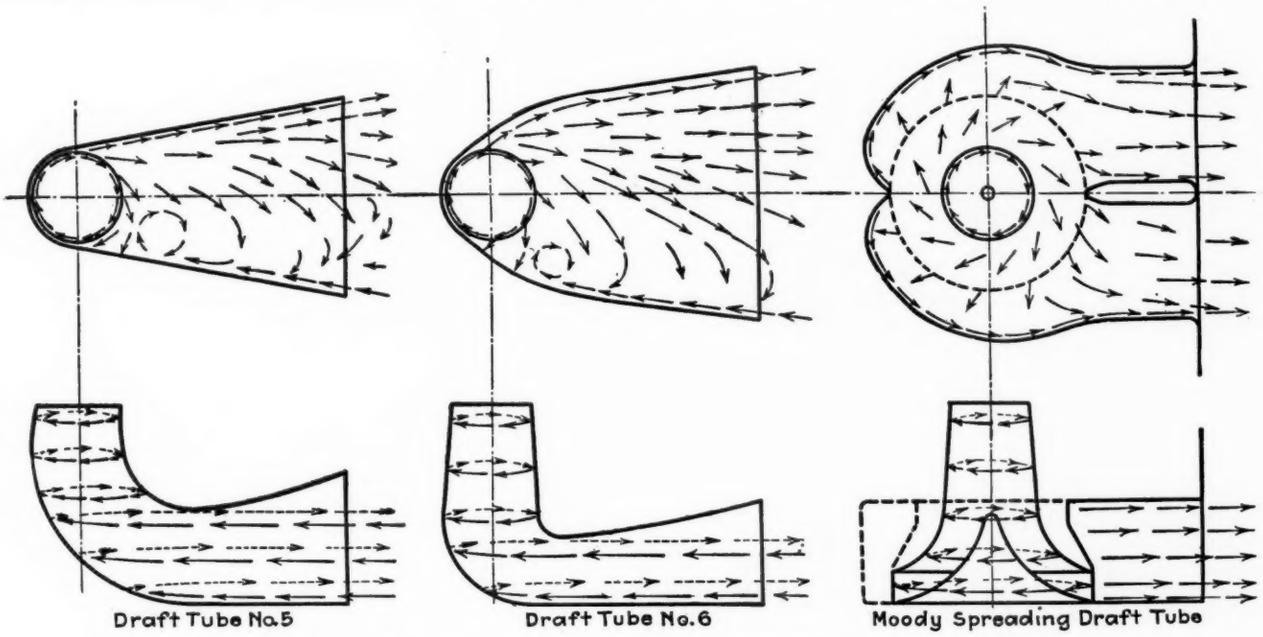


FIG. 6. DIFFERENT TYPE OF DRAFT-TUBE DESIGNS

It will be noted from Fig. 4 that the leakage water must pass through a series of six seals at each of which the velocity head is destroyed. Hence the effective head causing the leakage is only one-sixth of the head that causes leakage in the single seal. In the particular design shown, therefore, the labyrinth seals will reduce the leakage to about 3.9 cu.ft. per sec., or about 0.9 per cent of the full-load quantity.

It has been shown that for low-head installations where high-speed type runners are used the velocities at the discharge of the runner, D_2, are proportionately large. Fig. 5 shows curves plotted from average values taken from a number of typical Francis runners. The velocities at the top of the draft tube are expressed

as velocity heads and plotted as percentages of the total heads for various specific speeds. As the water does not usually leave the runner in a direction parallel to the axis of the draft tube there are two components of velocity to be considered: (1) The axial velocity as shown by curve *A*, and (2) the tangential, or velocity of whirl, as shown by curve *B*.

It is seen that for high specific speeds both of these items become of importance. Thus for a specific speed of 80, which has been previously considered in this article, the energy at the discharge of the runner to be regained in the draft tube amounts to 11 per cent of the total available head for the axial velocity, and 6 per cent of the total head for the whirl velocity. As velocity heads are used in plotting these curves the total energy to be regained in the draft tube is represented by the sum of these values. For high-speed runners, therefore, draft-tube design is of great importance, for no matter how efficient the runner may be in itself, for the case assumed in the foregoing, it is possible to lose 17 per cent of the total head with a design of draft tube which fails to regain any of the velocity. From the curves it is seen that for low specific speeds, such as 20, the axial component is less than 2 per cent of the total head and the whirl component is entirely negligible. Therefore, for low specific speeds the design of the draft tube is not important from a viewpoint of efficiency.

The problem confronting the designer of high-speed turbines is therefore to economically construct a draft tube that will regain as much as possible of the energy existing at the discharge of the runner. A long straight draft tube with a small angle of diffusion is probably the most efficient design, but for large units such construction would involve costly excavation and hence some form of curved tube must be adopted. Fig. 6 shows different types of draft-tube designs. The losses due to change in direction of flow are severe. The water leaving the runner is whirling in the same direc-

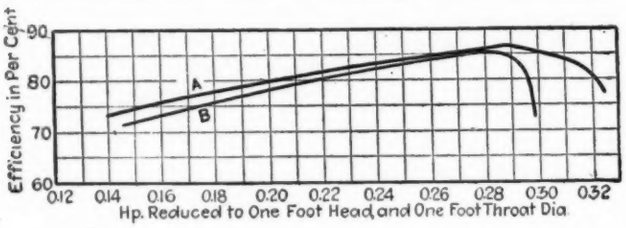


FIG. 7. EFFICIENCIES OF TURBINES AS AFFECTED BY DRAFT-TUBE DESIGN

tion as the runner rotates, the center of the vortex being the vertical axis of the draft tube. This vortex tends to remain in the same plane owing to its gyroscopic properties and will not, therefore, follow the center line of the curved type tube. As indicated in the figure, with this type of tube serious eddies and whirls occur in the curved portion, so that at the discharge of the draft tube it is usually found that but a portion of the discharge area is effective. Water from the tailrace actually flows in the reverse direction back into part of the tube, thus causing serious eddy losses and high outflow losses in the other portion of the tube. Tube No. 6 in the figure is slightly better than tube No. 5 owing to the fact that the straight portion of the tube is longer and hence the whirl components are somewhat reduced before the water enters the curved portion of the tube.

An ideal type of draft tube is the Moody Spreading type, as in this tube all sections are symmetrical with respect to the vertical center line and hence the whirl at the discharge of the runner is reduced to a low value before the water is discharged into the surrounding chamber. This design of tube, therefore, not only regains the axial component, but also most of the whirl component. Tests made on models of the draft tubes shown, not, however, in conjunction with a runner,

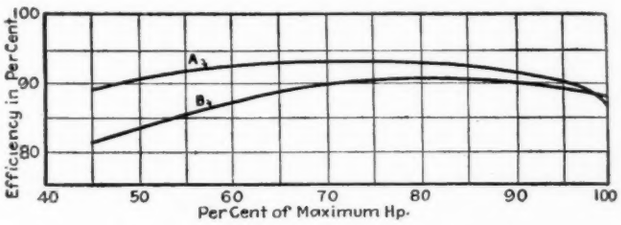


FIG. 8. EFFICIENCIES OF TURBINE AS AFFECTED BY DRAFT-TUBE DESIGN. TESTS MADE AT NIAGARA FALLS

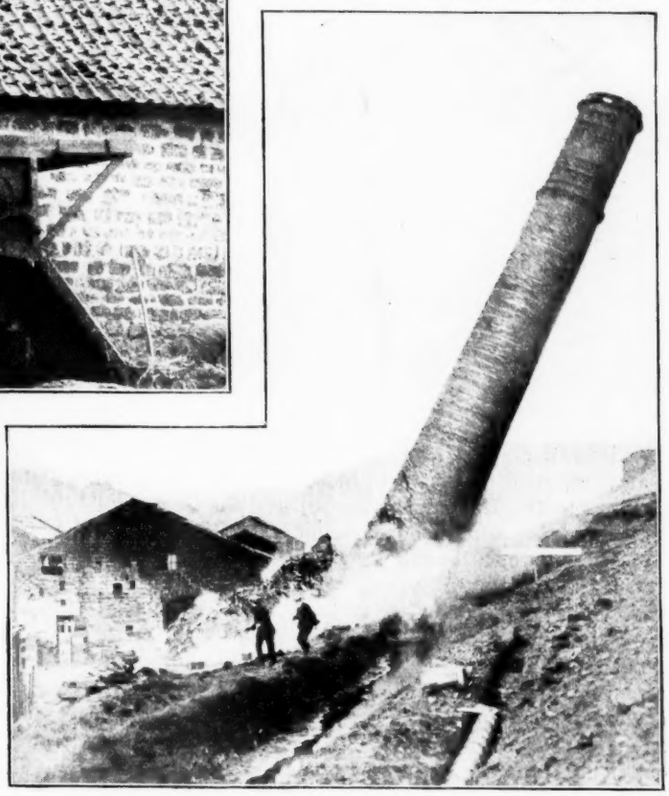
indicate that the Moody Spreading tube is about 10 per cent higher in efficiency than the curved tubes. As no runner was used in these tests the flow of the water was all axial, and undoubtedly in actual practice, where there is a whirl component from the runner the efficiency difference would be considerably more. In fact, a strongly whirling flow in a bent tube may readily cause losses exceeding the entire initial velocity head.

Tests have been made in the I. P. Morris Hydraulic Laboratory on Petty's Island of a turbine runner installed with each of the types of draft tube, Fig. 6, so that all the conditions during these tests were identical with the exception of the draft tubes. The results given in Fig. 7, therefore, accurately show the effect on the performance and efficiency of the entire turbine with the different types of tubes. Curve *A* was obtained from a high-speed runner with the Moody Spreading tube and curve *B* the same runner installed with curved tube No. 5, Fig. 6. It should be noted that at the point of maximum efficiency the spreading tube gives an efficiency of the entire turbine which is over 1 per cent higher than the results obtained with the curved tube, and that this difference in efficiency is greater at part loads, due to the fact that the whirl component is greater.

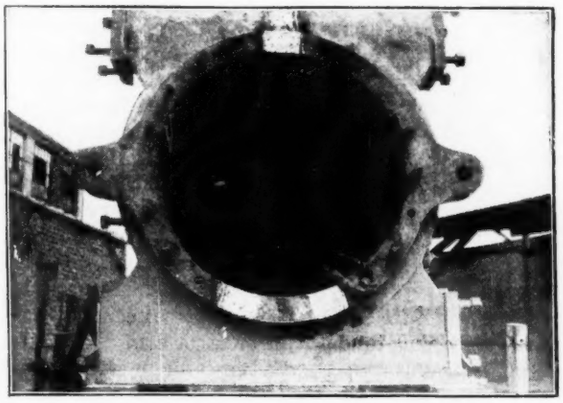
Fig. 8 shows a comparison between recent tests made on two of the 37,500-hp. units installed in the new station of the Niagara Falls Power Co. and the tests made several years ago on the 10,000-hp. units installed in that company's station No. 3. The 37,500-hp. turbines are of the vertical shaft, single-runner type, the specific speed is 35.5, the runner is furnished with labyrinth seals and the draft tube is of the spreading type; whereas the 10,000-hp. turbine is of the horizontal shaft type, the specific speed is 26.5, the runner has single straight seals, and the draft tube is of the curved type. Curve *A* is that of the 37,500-hp. unit, where curve *B* was obtained from the 10,000-hp. unit. The gain in efficiency of the modern-type turbine as compared with the older type, particularly at part loads, is noteworthy. Although in a prior installation a maximum efficiency exceeding 93 per cent has been obtained, yet it is believed that the average efficiency throughout the entire range of power for the two 37,500-hp. Niagara turbines is the highest ever attained.

One horsepower—getting back to fundamentals. As the horse tries to walk up the incline he moves the treadmill and operates the threshing machine. This type of "engine" is common in northern France and is also found in the New England States.

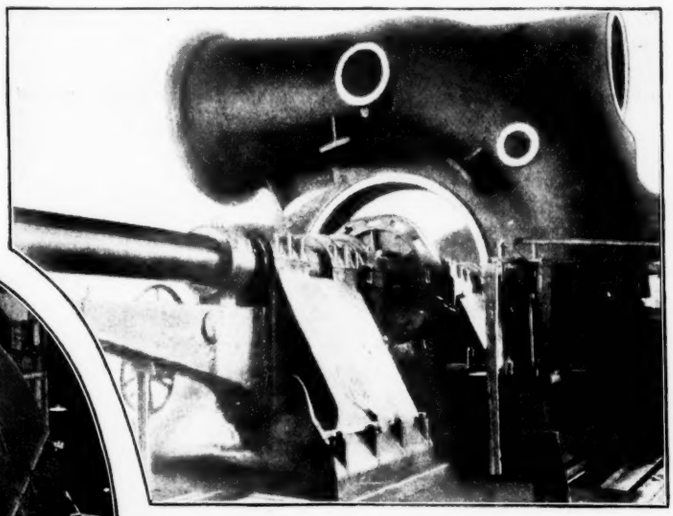
Felling a brick stack in England.

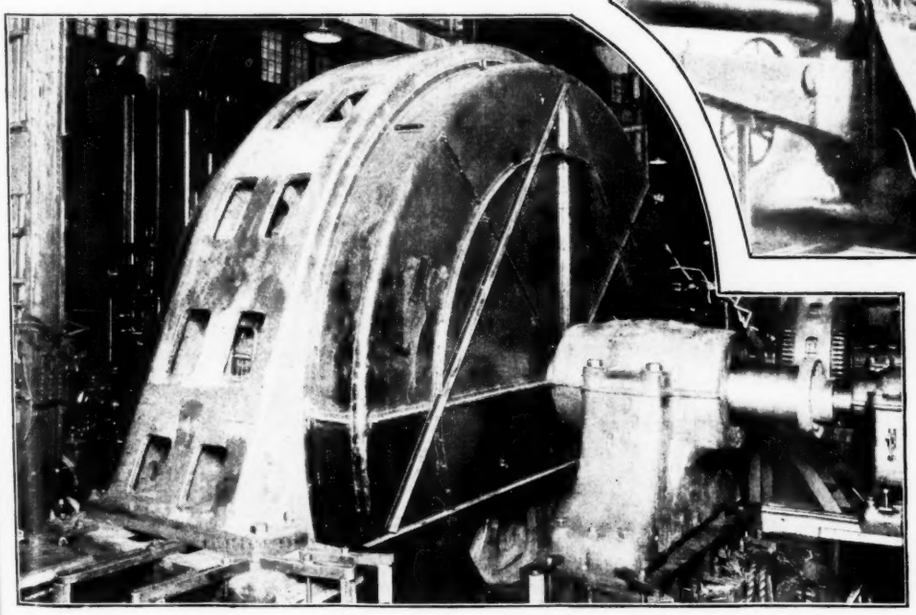


Half of the scroll case of a 9,000-hp. water turbine being machined in the shops of the Hooven, Owens, Rentschler Co. The other half was machined on a vertical boring mill, but this one was so large that it had to be put on the horizontal mill, as shown in this photograph.



The breaking of this cylinder of a 36 x 48-in. Corliss engine forced a large plant to shut down in the spring of 1920. It was repaired by oxyacetylene welding, however, within about ten days and has been in operation ever since.





The largest horizontal waterwheel driven generator ever built by the G. E. Co. It is to be installed in the Great Meadow plant of the Great Western Power Co., of California, where it will operate on a 165,000-volt transmission line. The machine is three-phase 60-cycle, rated at 22,222 kva., 0.9 power factor, 11,000 volts, 171 r.p.m. The total height over all is 21 feet and the weight is 334,000 lb. It is claimed that tests showed 97.25 per cent efficiency at full load, 95 per cent at half load and 93 per cent at quarter load, all at 0.9 power factor. The machine is shown here set up for testing at the factory.

Operation of Direct-Current Machinery with Compensating Windings

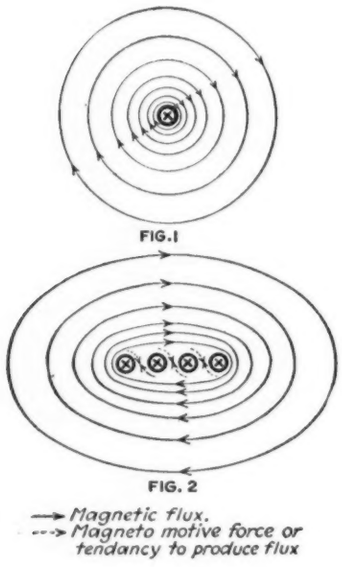
By H. M. Phillips*

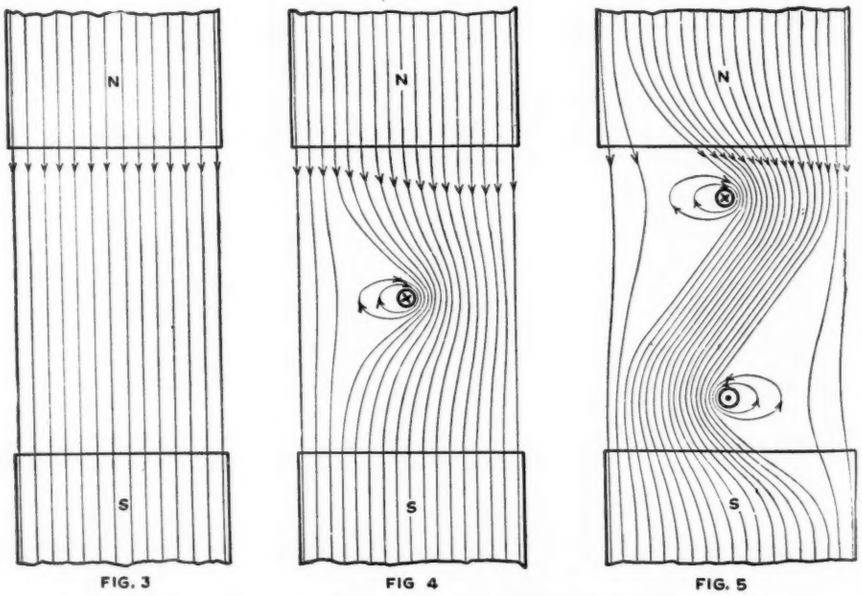
INTERPOLE windings are now in service on the majority of direct-current motors and on many generators in the United States, but compensating windings cannot be said to be commonly employed even at the present date, although they have been utilized to a certain extent for many years. The merits of these windings for abnormal conditions of service are now widely recognized, and prominent manufacturers find it advisable to provide them on certain classes of machines. The primary object of the compensating winding is to overcome commutation difficulties arising wholly or in part from the distorting effect of the current in the armature conductors upon the main field. Field distortion is the source of many troubles both in commutation and in general operation under variable loads, and a brief description of the way this distortion is produced will make for a clearer understanding of the rôle of interpoles and compensating windings, and their respective fields of action.

Electromagnetic Principles Governing Armature Reaction and Field Distortion—Effect of Distortion on Commutation and General Operation—Correction of Commutating Troubles with Interpoles—Correction of General Operating Troubles with Compensating Windings—Field Distribution in Interpole and Compensated Machines

A conductor carrying current tends to produce a field represented in Fig. 1; this field is actually produced in air by an isolated conductor free from disturbing influences. The direction and intensity of the field may be greatly altered by the influence of other currents or by the proximity of iron, where the same tendency to produce flux, or magnetomotive force, will produce a much stronger field than in air. If one or more conductors carrying the same current in the same direction are placed close to the original conductor, as in Fig. 2, they will tend to produce flux in opposite directions between any two conductors and in the same direction around the group of conductors as a whole,

*Electrical Aid, Public Works Department, Navy Yard, Washington, D. C.





FIGS. 1 TO 5. ACTION OF CURRENT-CARRYING CONDUCTORS ON MAGNETIC FIELD

Fig. 1—Field of isolated conductor. Fig. 2—Field of four conductors grouped. Fig. 3—Uniform magnetic field. Fig. 4—Isolated conductor in uniform field. Fig. 5—Pair of conductors carrying current in opposite directions in uniform field

the result being no field through the group and a field enveloping it approximately proportional to the number of conductors.

If the current-carrying conductor shown in Fig. 1 is placed in the uniform field shown in Fig. 3, the flux above the wire will be diverted to the right, and that below the conductor will be drawn back to the left, thus crowding the field over to one side, as illustrated in Fig. 4; the field to the left of the wire will be weakened by the crowding effect, and that to the right of the wire will be strengthened, the final result being a "distorted" field in the vicinity of the wire. Fig. 5 shows the combined effect on a uniform magnetic field of two conductors carrying current in opposite directions, which increases very materially the distorting effect. If the conductors are placed close to the iron polepieces, as in Fig. 5, the effect is to crowd the field under one side of the pole and weaken it on the other.

Fig. 6 illustrates the circuits of a two-pole generator. With current flowing in the armature in the direction indicated, each pair of conductors carrying current in opposite directions will act as in Fig. 5, and the combined effect will be to crowd the whole field over in the direction of rotation, the magnetomotive force of each individual armature conductor tending to force the field over to the right in the upper half and to the left in the lower half of the figure. Considering this effect from a different viewpoint, the north pole of the armature *Na* (Fig. 6) repels the north pole of the main field *N* and forces the flux from the latter over to the other side of the polepiece; the same action takes place between the south poles. The total flux, however, will remain approximately the same, though there may be a slight reduction of the total on account of the increased resistance offered by overcrowded or saturated pole tips.

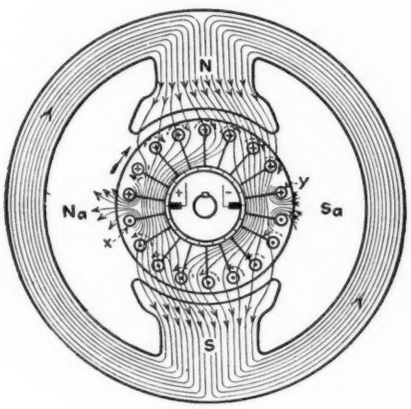


FIG. 6

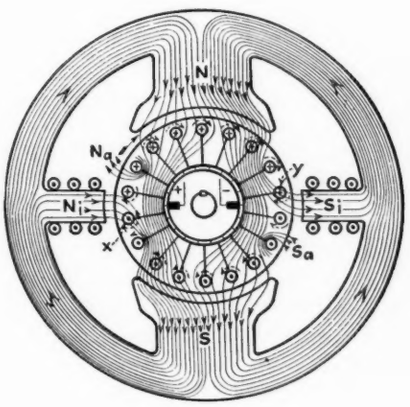


FIG. 7

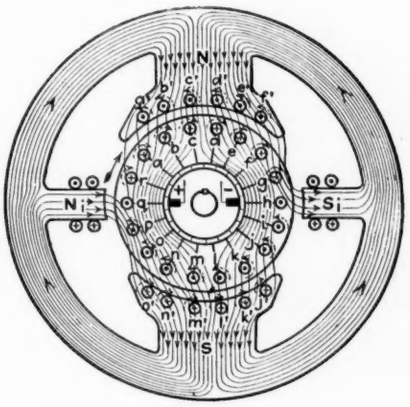


FIG. 8

FIGS. 6 TO 8. MAGNETIC FIELD IN A TWO-POLE DIRECT-CURRENT GENERATOR

Fig. 6—Flux distribution in simple generator, showing field distortion by armature reaction. Fig. 7—Flux distribution with interpoles, showing increased field-distortion. Fig. 8—Flux distribution with compensating windings, showing elimination of distortion.

Effect of Distortion on Commutation

Distortion of the field, as described, may or may not affect the commutation of the machine; in the majority of cases it does have an injurious effect; but even if it were entirely eliminated, it would be impossible to obtain satisfactory commutation under fluctuating loads without the use of an interpole winding, as may be seen by a brief consideration of the conditions necessary for theoretically perfect commutation.

During the period that two commutator bars are under a brush, the coil connecting the bars—for example, coil *xy* in Fig. 6,—is short-circuited. If the opening of this short-circuit, as a commutator bar emerges from beneath the brush, causes an abrupt change in the amount or direction of the current flowing in the coil, the self-inductance of the coil, or "magnetic inertia," will tend to resist the change, and sparking will result. Under no-load conditions there would be no current flowing in the coil both before and after commutation other than the field exciting current which is small and may be neglected; therefore there should be no flow in the coil during the period of short-circuit; this means that these conductors must not be cutting a magnetic field while under commutation, as this would generate voltage and cause a current to flow. This condition is ordinarily fulfilled by setting the brushes so that a coil is midway between two poles or on the neutral axis at the time of commutation.

Considering in the next place the case of the armature under load and assuming the field of the same strength and distribution as at no load and not distorted, the coil approaching the commutating point is carrying current which, owing to the self-inductance of the coil, will be but slightly reduced during the brief period of short-circuit. This current will have to be suddenly reversed when the short-circuit is opened and the coil becomes a part of the other circuit through the armature, and this reversal of current will cause pronounced sparking, in spite of the absence of field distortion. To avoid this sparking, the coil, while short-circuited, should be cutting flux of proper strength and direction to generate an electromotive force opposed to the current, which will reverse it and build it up in the opposite direction at such a rate that it will become equal to the armature current, just as the commutator bar emerges from under the brush. There will then be no change of current in the coil as it becomes part of the other armature circuit, and therefore no sparking will occur.

The whole problem of good commutation therefore rests on this commutating field. Referring to Fig. 6, the armature conductors lying between the poles on both sides of the conductors *x* and *y* set up a field which these conductors must cut while still short-circuited, and the direction of this field is such as to generate voltage

in the same direction as the short-circuit current in the coil *xy*, thus opposing the reversal of current instead of assisting it, and thereby increasing the difficulty of commutation. It is therefore necessary, in order to obtain good commutation, to eliminate the armature flux and to provide a weak field in the opposite direction from an outside source to overcome the self-inductive effect and reverse the current.

In the absence of interpoles the armature flux may be neutralized by shifting the brushes with increasing loads (in the direction of rotation for a generator and the reverse direction for a motor) so as to bring the axis of commutation within the fringes of the main field, where it is usually possible by trial to find a field of proper strength and direction to give sparkless commutation. Distortion of the main field, however, by progressively forcing the flux over to the other pole tip as the load increases, adds to the distance that the brushes must be shifted to obtain the proper commutating field; and since this distortion increases with the load, the brushes will have to be shifted more and more as the load rises. Moreover, distortion may make the change from a weak field to a strong one so abrupt that it will be impossible to obtain the correct field strength. This method is therefore unsuitable for fluctuating loads.

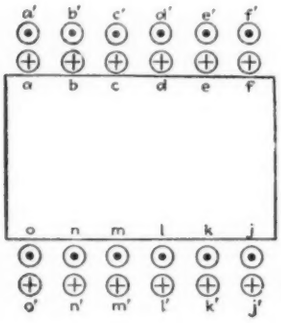


FIG. 9. ILLUSTRATING COMPENSATING EFFECT

The necessity of shifting the brushes may be avoided by placing a small auxiliary pole or "interpole" directly

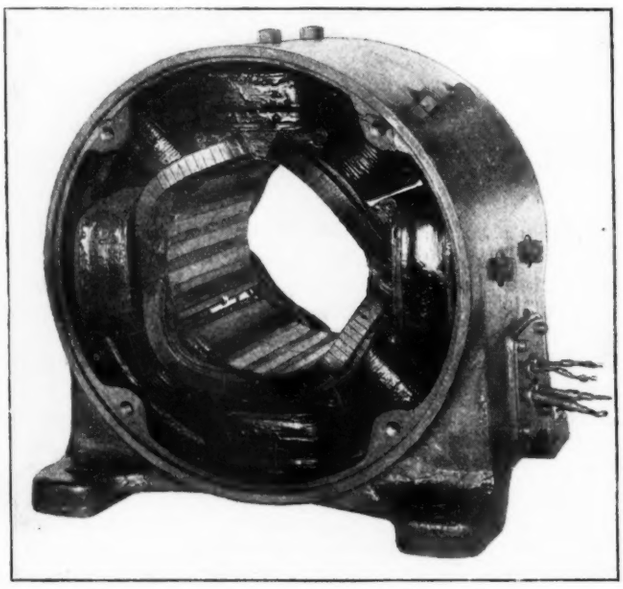


FIG. 10. FOUR-POLE COMPENSATED MOTOR WITH INTERPOLES

over the point of no-load commutation, so as to oppose and neutralize the magnetomotive force of the armature and give sufficient field in the right direction for sparkless commutation. Since the excitation of the interpole must increase with the load, its windings may be placed in series with the armature. It is commonly claimed that this connection will give exactly the right strength of commutating field at all loads. This statement is not strictly correct, on account of the influence of magnetic saturation, air gap, distorted main field and possibly other disturbing factors, but satisfactory commutation even with heavy overloads may be

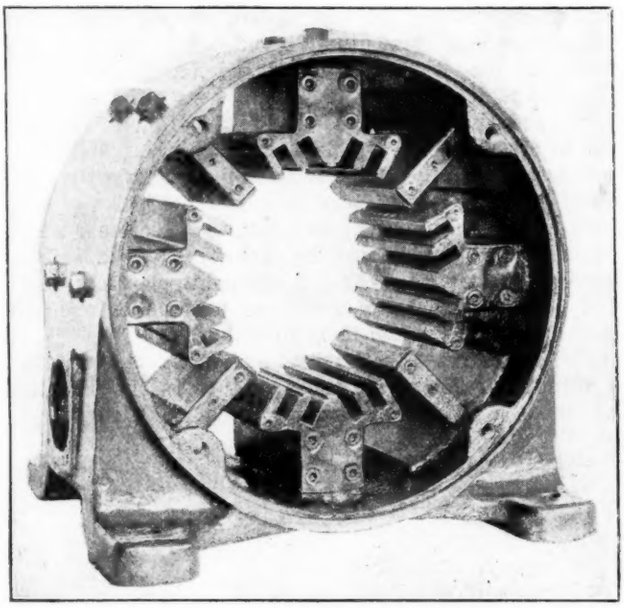


FIG. 11. FRAME OF MACHINE, FIG. 10, SHOWING SLOTS IN POLE FACE FOR COMPENSATING WINDINGS

obtained in most cases with properly designed interpoles.

It should be emphasized at this point that the interpole, though it does for all practical purposes eliminate all commutation troubles arising from field distortion, by no means eliminates the distortion itself; on the contrary, it increases it slightly, as may be seen in Fig. 7, for inasmuch as the commutating flux cannot flow from the auxiliary north pole to the main north pole, it is forced to flow through the already overcrowded tip of the main south pole. Furthermore, the interpoles neutralize the magnetomotive force of only a part of the armature conductors between poles; this has the effect of shifting the armature north and south poles, *Na* and *Sa*, Fig. 7, nearer the main north and south poles and so increasing the repulsion between them.

Service Conditions Under Which Distortion Is Detrimental

Aside from commutation troubles field distortion has several ill effects on general operation, which are particularly objectionable in high-speed machines and in large machines subjected to sudden and heavy overloads. For instance, in high-speed machines where there are few bars between brushes and high voltages generated per coil, it is very difficult to keep the voltage between commutator bars within safe limits. Field distortion, by causing excessive voltages between bars in the denser portions of the field, increases the possibilities of insulation failure between bars or, under sudden loads, flashing over at the commutator. Field distortion is also objectionable in machines with a large number of poles; for the space between poles in which the interpole must be located is so small that it is difficult to prevent the distorted main field from encroaching on

the interpole. In the case of high-speed machines or of large machines subjected to variable conditions of loading, such as rolling-mill motors, it is therefore important to eliminate field distortion.

This is accomplished by providing in the pole face opposite each armature conductor a conductor carrying the

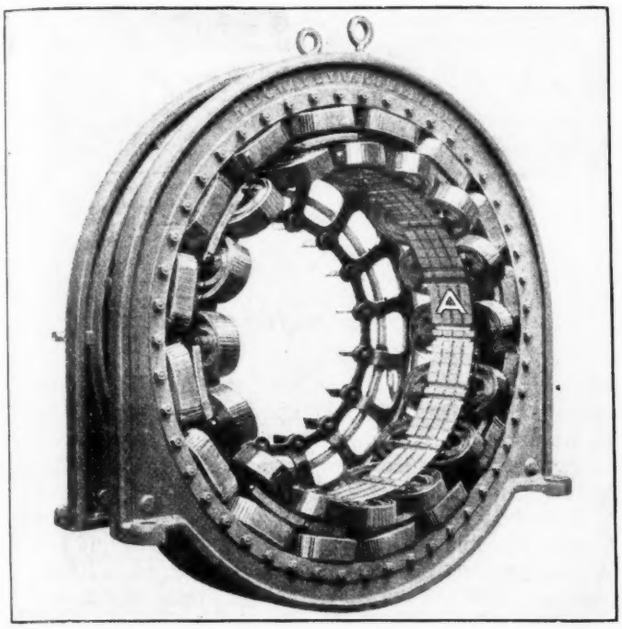


FIG. 12. GENERATOR WITH INTERPOLES AND ECCENTRIC COMPENSATING WINDING FOR COMPOUNDING

same current in the opposite direction. Referring to Fig. 8, it may be seen that, whereas the tendency of the conductors in the upper half of the armature is to throw the flux off to the right, the compensating conductors throw it off to the left, producing a slight wave in the flux as it flows through the two windings. The net result is a practically uniform distribution of flux across the pole face.

A somewhat simpler conception of this action is to consider the compensating and armature windings as two concentric coils or solenoids opposing each other and tending to produce flux in opposite directions, as shown in Fig. 9, thus neutralizing each other. The armature reaction being overcome, a weak interpole winding will be sufficient to provide a satisfactory commutating field. Both the compensating winding and the interpoles should be connected in series with the armature. In practice the compensating winding is placed in slots in the face of the main poles and, for the sake of greater simplicity and economy, concentrated in three or four slots, with two or more conductors per slot, one slot in the pole face neutralizing two or more in the armature.

Examples of Compensated Machines

The application of the compensating winding to a four-pole motor is shown by Figs. 10 and 11. In this case the polepieces of the main field are somewhat wider and deeper than would otherwise be the case and carry the compensating winding in four slots in each polepiece. The motor in question was designed for variable speed, ratio 4 to 1, and direct connection to such machines as planers and slotters of large capacity. The motor reverses automatically at each stroke of the machine and makes the return stroke at approximately double the speed of the cutting stroke. In order to decrease the inertia of the armature, it is made considerably smaller in diameter and of greater length than the ordinary armature of the same capacity, which gives less than the normal number of commutator bars, with a correspondingly higher voltage between bars. Dynamic braking, which is in fact operating the motor as a heavily loaded generator, is used to bring the motor to a sudden stop prior to reversal. The frequent starting and stopping, the high acceleration and practically instantaneous stopping, both necessitate very high armature currents and render commutation difficult. Carefully designed interpoles and compensating windings are therefore vital to the success of electric drive in this particular case.

One of the most important applications of compensating windings and interpoles is in electric motors for rolling mills. Rolling-mill motors are of very large capacity and slow speed, therefore have a large number of poles. They are subjected to the most extreme conditions of variable loading, and satisfactory commutation would be impossible without complete compensation of armature reaction.

The application of the compensating winding to a generator is illustrated by Figs. 12 and 13. A noticeable feature of this machine is the small size and close spacing of the shunt-field coils which form the outer circles of coils in the frame. There is a rudimentary interpole carried between the adjacent main poles by wedges of non-magnetic material; it does not extend back of the line of the polepieces, and there is consequently no encroachment on the space required for the shunt-field coils. The combined interpole and compen-

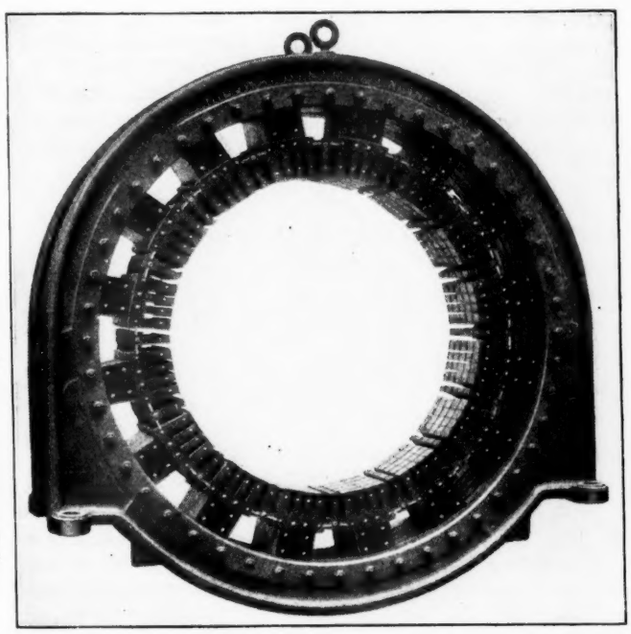


FIG. 13. FRAME OF MACHINE, FIG. 12, SHOWING SLOTS IN POLE FACE AND RUDIMENTARY INTERPOLES

sating winding consisting of copper ribbon, properly insulated, is started on the interpole and, after making one or more turns, is carried on to the adjoining slots in the polepiece, as is shown quite clearly in the illustration. Generators of this type have been known to give sparkless commutation under 300 per cent overload.

If an "eccentric" winding is used for compensation, it will perform the function of an ordinary series winding in compounding or overcompounding the generator. This type of winding is clearly illustrated in Fig. 12. The compensating coils are not centered on the interpole, but occupy two slots in the pole face on one side of the interpole and one slot in the pole face on the other side. This machine lacks the flexibility of the ordinary compound generator, with or without interpoles, inasmuch as it cannot readily be operated as a motor or in the reverse direction to that for which it was designed. The compound interpole generator, when operated as a motor, must have the connections of its series field reversed in order to prevent it from weakening instead of strengthening the shunt field as load is applied, but the connection of the interpole to the armature must remain unchanged. In order to operate this machine as a generator with reverse rotation, it is necessary to reverse the connections on both the shunt and series fields, leaving the armature and interpole connection unchanged. This difficulty exists entirely with the eccentric compensating winding. If a concentric winding is used, a separate compound winding may be employed and the generator reversed or operated as a motor.

Field Distribution in Interpole and Compensated Machines

The exact distribution of the magnetic field about the armature may be recorded with great accuracy by means of the oscillograph. A fine wire is secured directly over an armature coil, on one side of the armature only, and the ends brought out to slip rings on the shaft. The voltage generated in this wire is at any instant exactly proportional to the strength of the field in which it is moving. The oscillograph itself is essentially a galvanometer of such delicate construction that it is able to follow with accuracy all fluctuations of voltage and record them by the reflection of a ray of light from a moving mirror upon a rapidly moving photographic

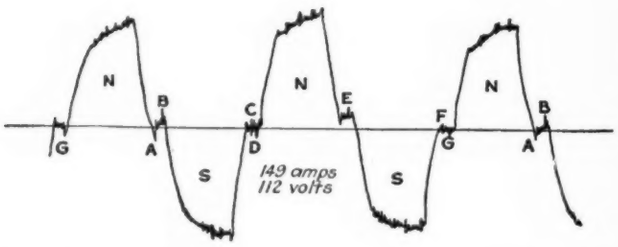


FIG. 14. OSCILLOGRAM SHOWING FLUX DISTRIBUTION IN FOUR-POLE INTERPOLE GENERATOR

film. Fig. 14 is an oscillogram taken from a small four-pole interpole generator and shows several imperfections in construction or design. It will be noticed that the four fields are not of exactly equal strength, perhaps owing to the armature being slightly out of center. One interpole only gives a pronounced reversal of field for commutation, at *A*, Fig. 14. Two, at *C* and *F*, are only strong enough to neutralize the armature flux through the coil under commutation, without supplying a reversing field. The fourth, at *E*, is too weak even to neutralize the armature flux, and during commutation voltage is still being generated in the direction to oppose the reversal of current. Field distortion, which is inherent to the interpole construction, is plainly evident. The momentary reversals of magnetism at *B*, *D* and *G*, just as the pilot coil enters the main field, are due to the armature flux between the interpole and main poles (Fig. 7).

The field of a compensated generator, shown in Fig. 15, requires little explanation. The three indentations in the flat top of the main field are caused by the slots

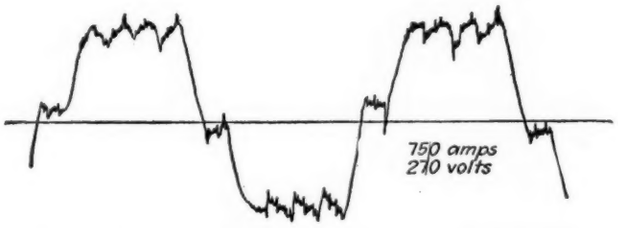


FIG. 15. OSCILLOGRAM SHOWING FLUX DISTRIBUTION IN MULTI-POLE COMPENSATED GENERATOR

which carry the compensating winding; but the field as a whole is not distorted and shows a machine from which we might reasonably expect a better performance under excessive overload than from the one in Fig. 14. Moreover, this machine is of the type illustrated by Figs. 12 and 13, with main fields so closely spaced that if it were possible to introduce interpoles without the compensating windings, they would be so crowded that the encroachment of the distorted field upon the interpole would be more marked than in Fig. 14.

Republic CO_2 Recorder

To meet the demand for a simple and reliable CO_2 recorder the Republic Flow Meters Co., of Chicago, has perfected the instrument shown in the accompanying illustrations. The chart and recording mechanism are secured to the cover, and the analyzing units are arranged in a case measuring 22 x 13 x 5 in., the entire instrument weighing 50 lb. Glassware has been replaced by copper pipettes and tubing. Samples are analyzed at certain fixed intervals. When the recorder is in operation, water is admitted by the tube *A*, Fig. 2, through the coil in the oil seal to maintain a constant temperature at this point. The tube then passes to the top of the case, and the water flows through a jet at *B* and an aspirator *C* into the large container *D*.

FIG. 1. REPUBLIC CO_2 RECORDER

A gas container, placed at the back and top of the instrument case, has a dividing wall separating the inlet from the outlet, a small passage being left between the end of the baffle and the end of the container farthest from the inlet. Near the jet *B* a connection is made between the tube *A* and the outlet side of the gas container. To this cross-connection is tapped a vent which rises to the top of the case and drops into the reservoir *D*, ending at a level above the point *F*. Tube *U* connects to the inlet side of the gas container. Water flowing through the jet *B* forms a partial vacuum in the gas container, and thus draws the gas from the boiler furnace. The sample for analyzing is drawn from the container through the tube *U*. So long as the water level in the reservoir *D* is below the outlet of the vent line connected between *B* and the gas container, atmospheric pressure exists in the gas container regardless of the condition of the gas line to the furnace. As soon as the vent referred to is covered by the rising water, a vacuum is produced in the gas container and a continuous supply of gas is drawn in.

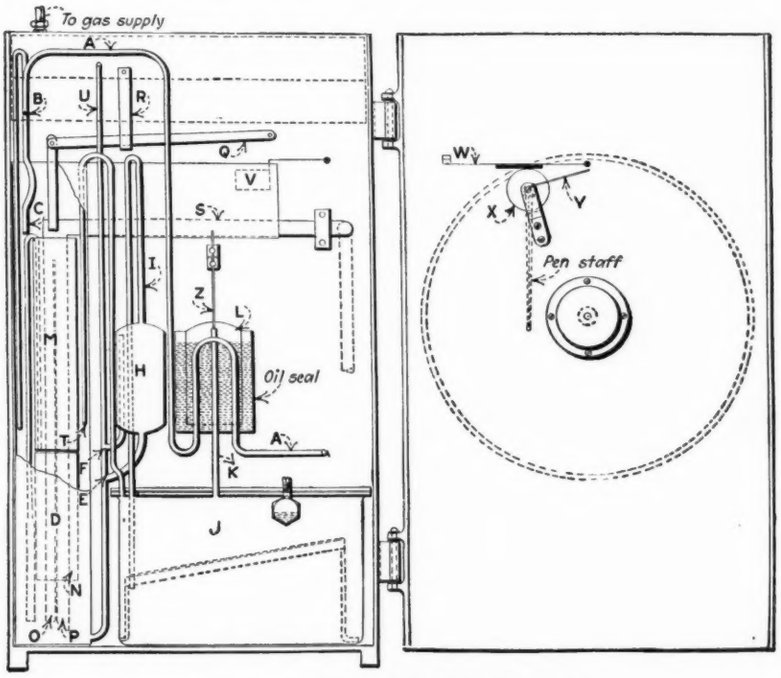


FIG. 2. DIAGRAM OF CONNECTIONS

As the water rises in the large container *D*, it also rises in the vertical tube *U* connected near the bottom of the container. When the water reaches the branches *E* and *F*, it seals off a definite volume of gas in the pipette *H*. As the water continues to rise, it fills the pipette *H* and forces the gas through the tube *I* into the tank *J*, which contains a potash solution. The gas passes through the solution under the baffle for its entire length and rises to the surface. During this passage the CO_2 contained in the gas is absorbed, leaving an amount of residue gas which escapes through the outlet *K* into the space under the float *L* in the oil seal, causing the float to rise to a height proportionate to the amount of residue gas.

As the water reaches its maximum height, it raises the float *V*, which in turn lifts the arm *W* and the weight on this arm resting on the friction wheel *X*. This action causes the pen on the pen staff to register the percentage of CO_2. As soon as the water falls, the float *V* lowers with it, permitting the weight to drop back on the friction wheel and hold the pen in position to make a continuous line record until another analysis is taken. Depending upon a flow of water, the interval between analyses varies from 2 to 2¼ minutes.

Water in the container is removed by a siphoning system consisting of open floats *M* and *N* connected to the tubes *O* and *P*. These floats move the outlet to the siphoning system above the water level until the water reaches its highest point, when the arm *Q* strikes on guide *R*, thus holding the floats stationary and allowing the water to overflow into them. When sufficient water has entered, the floats sink and pull the outlet of the siphoning system below the water level, giving a head of water to start the siphon emptying the container. As the water is siphoned out through tubes *S*, *O* and *P* to waste and the water level is lowered below the point *T*, thus releasing the seal leading to the caustic potash tank, the residue gas from this tank and underneath the float escapes to the atmosphere.

When the receding water reaches the point *F*, the pipette *H* discharges through *E* into the pipe *U*, and at the same time through the connection *F* and the pipe *U* a charge of gas is drawn from the container at the top of the case. The gas container at the back of the case does not cause a "lag" in the operation of the instrument as the sample of gas is drawn from the inlet compartment. When the water is lowered to the point *O*, air is admitted to break the vacuum and the siphoning action stops. A secondary siphon empties the float. Reservoir *D* then begins to fill with water and the same cycle of operation is repeated.

A gage on the front of the potash tank shows the level of the liquid at all times. A valve at the bottom of this tank is for draining the contents to the waste pipe when it is desired to renew the solution.

Careful damper regulation is essential when oil fuel is used. If the attendant is burning coal and forgets to open the damper before firing up after a shutdown, there may not be an explosion of confined coal gas, but with oil fuel it is extremely dangerous to start the fire or admit any oil to the furnace until after the damper may have been opened at least a few seconds; but fuel oil is converted into gas very quickly by relatively low temperatures, and the explosive power of this gas is considerable, so unless the damper is opened wide before oil is admitted to the furnace, a violent explosion is likely to occur and not merely blow down a portion of the boiler walls, but injure the attendant as well.—*Warren Hilleary.*

The breeching, or connection between a boiler and chimney should be kept clean and free from soot. All breechings should have doors for easy access. All joints should be made tight and the breeching kept clean on the interior; soot should be removed from the base of the chimney at intervals.

Adjusting Crankpin Bearings on a Vertical Diesel Engine

By LOUIS R. FORD

CRANKPIN and crosshead bearings of vertical Diesel engines require more attention than any other bearings, and the periodical reversal of pressure, such as occurs in the four-stroke-cycle engine, causes these bearings to pound badly if the clearance is too great. With marine engines most of the bearing adjustment is done during the more or less short periods when the ship is receiving or discharging cargo. In the case of either stationary or marine engines the shutdown period is hardly ever more than 48 hours and usually 24 hours, so the engineer must be able to make his adjustments with dispatch. During the time the engine is running the bearings that need attention may be determined and the necessary preparation for the work made before the engine is stopped, including the assembling of all the tools necessary to climb out of a crankpit and go to the storeroom for a wrench that could have been placed handy to the work before starting. The first requisite for easy handling of crankpin boxes is a means for supporting the weight of the piston, piston rod, crosshead, crosshead slipper and connecting rod, so that when the crankpin boxes are disconnected the crankpin may be turned away from, or up to, the rod. It should never be

The fundamental principles of bearing adjustment on Diesel engines are in no way different from the principles underlying similar adjustments on vertical steam engines, but operating and structural conditions have a strong influence on the methods of applying these principles on the Diesel engine

In the case of crosshead engines with the conventional slipper type of crosshead guide, the best method of support is to drill a hole through each side of the crosshead guide. By slipping a bolt or bar through these holes while the crosshead is in its upper position, the shaft can be jacked around until the crosshead slipper comes to rest on this bar and all the weight is taken off the crankpin. Unless the builders of the engine have provided such holes, the engineer in charge should drill them himself. Some builders are averse to providing them because of the possibility that the engineer may forget to remove the bar before starting the engine. Actually, however, there is no more reason for expecting this than to expect any one of the dozens of other mistakes of a similar nature that might occur in overhauling an engine.

The adjustment of a crankpin bearing on a large engine should proceed as follows: Suspend two small chain falls from any convenient point inside the housing for taking the weight of lower box. A very simple and useful device for use in this connection is shown in Fig. 1. A metal bar is bent to fit snugly over the forked end of the connecting rod, with an arm extending out on each side over the crankpin bolts, on which the chain falls may be suspended. A rope sling is attached to the lower crankpin box by means of eyebolts screwed into the side of the box or attached to the crankpin bolts by means of eyebolts screwed into the top of the bolts. If the lifting slings are attached to the box, the bearing bolts must be secured by setting up on the locking setscrews in the sides of the lower box, in order to prevent the bolts dropping out when the nuts are removed. If, however, the lifting slings are attached to the bolts themselves, this setscrew is not required. When the bottom box is lowered, the bolts go down with it and the lifting slings are allowed to pass down through the bolt holes. This, of course, necessitates jacking the shaft around until the crank being worked on is on center, in order to give a direct lead to the lifting gear, and this must be the top center, in order to provide room for handling the box under the shaft.

Before the crankpin nuts are loosened, the nuts and bolts must be marked on top with a light chisel cut, half on the nut and half on the bolt, so that when the box is replaced the nut can be brought back to exactly the same position. A better method is to make permanent marks on the bolt tops with one or more reference marks and make a series of permanent marks in a graduated circle around the inner periphery of the nut tops. With this arrangement it is not necessary to deface the bolts and nuts by making new marks each time; simply note the position of the nut by the graduated circle before loosening up.

After the position of the nuts is noted, loosen the nuts and take the weight of the box on the chain falls, take the nuts off and lower away with the chain falls until the lower box is clear of the pin. Lay three or more pieces of soft lead wire, depending on the length of the crankpin, on the surface of the babbitt in the box, at right angles to the fore-and-aft axis of the pin. Pull the box back up to position with the chain falls, put on the nuts and sledge them up to exactly the same position they occupied before loosening, as indicated by the marks. This mashes the lead wire flat and its thickness after being mashed down will be equal to the amount of clearance between the crank pin and the surface of the babbitt in the bottom box. This will be the total amount of clearance in the bearing, as the weight of the piston, piston rod, crosshead and connecting rod is pressing the top box tightly on the pin and its clearance is zero. Loosen the nuts again, lower away the box until the lead wire, or "leads" as they are commonly called, can be removed. By means of a micrometer the thickness of each lead can then be measured at different points along its length, and any variation in these measurements will indicate differences in the clearance. Since the surface of the crankpin is normally smooth, these variations will be due to high or low spots in the babbitt lining of the box. This method of measuring clearances is not absolutely accurate for the reasons that the wire may be so hard or so large that it will be forced into the babbitt, or the same thick-

ness of wire may not be used in each case. It is, however, accurate enough for all practical purposes and is the method commonly used in Diesel practice.

To reduce the chances for error, care should be exercised to see that the lead wire is soft enough for the purpose and is of the right diameter. This diameter is determined by the probable amount of clearance to be expected in the bearing being worked upon; if the wire, after being compressed in the bearing, is not materially reduced in thickness, it is either too small in diameter or is too hard. By all means do not use wire of different sizes or degrees of softness on the same job. If no lead wire is available, electric fuse wire is a satisfactory substitute. If the leads show the clearance to be very even over the bearing surface, adjustment is obtained by subtracting from the measured thickness of the wire the amount of clearance to which it is desired to set the bearing, the difference being the thickness of shims that must be removed from between the boxes. After removing the shims, put in another set of leads, put the box back in place and sledge the nuts up tight enough to insure good solid contact between the two boxes. Note the position of the nuts, open the bearing again and measure the leads to determine the correctness of the final clearance. Should this be too great or too small, some further subtraction or addition of shims will be necessary.

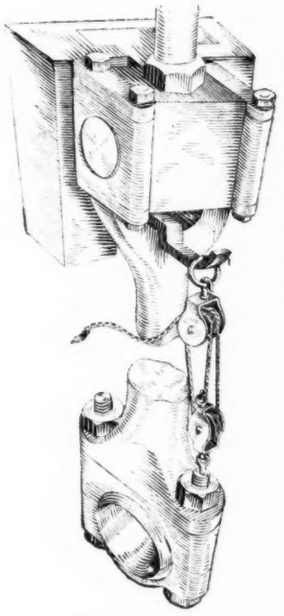


FIG. 1. LOWERING CRANK BEARING

Should the first leads taken show the babbitt to have high or low spots, the box must be lowered into the crankpit and the high spots scraped down with steel scrapers until a good, even bearing is secured. When scraping is required, it may be necessary to take several sets of leads before correct adjustment is secured.

Opinions differ as to the amount of running clearance to be allowed in different bearings. A safe rule for all large bearings is to make the clearance equal to the diameter of bearing in inches multiplied by 0.0005 in. plus 0.002 in., until experience with any particular engine proves more or less than this to be better. As a general rule it will be found that bearings supplied with forced lubrication will run quietly with more clearance than will those supplied with gravity lubrication, the reason for this being that with forced lubrication there is always a large excess of oil flowing through the bearing and it forms a cushion against shock.

The babbitt lining in the upper box should be examined to see if it is bearing evenly on the pin. This can be done by putting the supporting bar in place under the crosshead shoe, then jacking the shaft around until the moving parts above the crank are supported on the bar. As the shaft turns, the top box will follow the crankpin down, and when clear of the foot of the connecting rod, it may be lifted off for examination. Before doing this the lower box must be landed and the supporting slings pulled up out of the way.

If, on account of overheating or for any other reason, the bearing needs refitting, the boxes are removed from the pin in the manner just described, all roughened or wiped babbitt scraped out and the oil grooves cleaned out. The crankpin is wiped clean, then coated lightly with Prussian blue, lampblack or thin red lead. If one of the boxes is then placed on the pin and rotated back and forth, the high spots in the babbitt lining will be marked and can be scraped down. This procedure is repeated until a good, even bearing is obtained. This good bearing should not, however, extend out to the edges of the box. The babbitt should be scraped away at the edges, as shown in Fig. 2, the relieved part extending nearly, but not quite to the ends of the box. This relieving has two purposes, the principal one being to provide a wedge-shaped entry for the oil film between the surface of the bearing and the babbitt, the other to prevent the box seizing at the sides in case the bearing should heat. Some engineers are prone to the belief that a large number of oil grooves improves the oil distribution throughout the bearing, but it should be remembered that with forced lubrication a certain amount of resistance to oil flow within the bearing is necessary in order to prevent excessive loss of oil with consequent robbing of other bearings in the system. If oil grooves are cut in the babbitt a large amount of the oil will flow from the ends of the grooves to the nearest end of the bearing. These grooves also reduce the bearing area and increase the unit bearing pressure.

When making adjustments, a number of shims of various thicknesses will be required in order to make

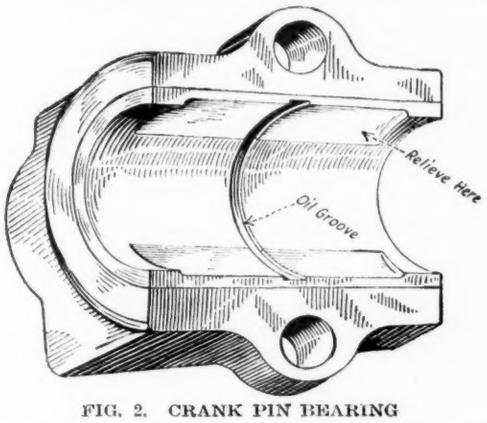


FIG. 2. CRANK PIN BEARING

up the right combination to give the total thickness necessary to produce the desired clearance. For fine adjustments, where paper shims are used, it should be remembered that the paper will compress and be reduced in thickness when squeezed up between the boxes, but if the same kind of paper is used all the time, it will, after a few trials, be possible to determine just how much allowance should be made.

When sledging up the nuts, great care must be exercised to prevent putting too much initial stress on the bolts. It is not possible to determine how much force is exerted on the wrench when it is struck by a sledge-hammer in the hands of first one man, then another, and many cases of bolts breaking because of being set up too tightly are known. The determination of the exact point at which good, solid contact between boxes and shims is assured, without overstressing the bolts, is a matter of judgment and experience.

Warming Buildings With Refrigerating Equipment

How Our Vast Natural Supply of Low-Temperature Heat May Be Utilized—A Parallel in Hydraulics—Lord Kelvin's Suggestion Susceptible of Economic Development

By ROBERTSON MATTHEWS*

AT LAST we are showing interest in the conservation of fuel. This agitation really means that we are growing anxious about our supply of high-temperature heat—that heat of high elevation (of temperature) which, like the water of Niagara, will of itself, because of its high elevation, flow to regions of lower elevation, and which, through the agency of engines, can be made to do for us useful work.

In the production of power that heat only is useful which has a higher elevation of temperature than the atmosphere. The laws of the expansion of gases and vapors make imperative the need of such high-temperature heat. But when heat is required to warm buildings, high-temperature heat, to the extent now used, is not an absolute essential.

Consider atmosphere at freezing temperature entering a building. The heat in that atmosphere requires to be raised in temperature only 38 deg. F. (that is up to 70 deg. F.) in order to satisfy ordinary room-temperature requirement. Why should we, then, have to use gases at a temperature over 2,000 deg. F. in order to raise the atmosphere through that small range of 28 deg. F.? Even the use for warming purposes of steam at 212 deg. F. means a misuse of high-temperature heat and of heat that costs money. Science proclaims the wisdom of using low-temperature heat for warming purposes.

In the myriads of tons of atmosphere and water on or surrounding this earth there is already stored an enormous quantity of heat—heat that keeps the air and water in their fluid state and at those temperatures which, compared with furnace and oil-engine temperatures, are never greatly below desired room temperature. But this heat is not available inside our dwellings in cold weather because heat, like water, will not, unaided, run up hill. Yet that air and water is a storehouse of heat—of low temperature heat—which but needs the provision of machinery and of effort to elevate it for use to that level (of temperature) at which we desire it.

The process of elevating this low-temperature heat, however, involves two considerations: (1) The means wherewith it can be done; (2) the commercial practicability. This commercial consideration calls for numerical values showing what the saving of high-temperature heat might be. As a start our scheme will be this: By the use of a small quantity of high-temperature heat to make available for warming purposes a much larger quantity of low-temperature heat.

Before we undertake, however, to consider what would be necessary in order to make low-temperature heat from the atmosphere available for warming buildings, let us get in mind some useful relationships by first seeing under what conditions an abundant supply of low-level water may be made available through the use of a lesser quantity of high-level water.

In Fig. 1 let the lake contain for our needs an unlimited quantity of water, ten feet below the level of the gardens, and therefore at present not available for irrigating them. Above, however, is a plateau where 1,000 cu.yd. of water can be accumulated in a pond, and from a height of 100 ft. supplied to the garden lands. But we need much more water than this 1,000 cu.yd. so let us run a turbine with the water from the pond, the turbine shall drive a pump, and the pump shall raise water from the lake to the gardens.

Will such a plan supply sufficient water? The calculations are simple. We know that a small weight moving through a long distance at the end of a lever, will raise one wheel of an automobile through a short distance.

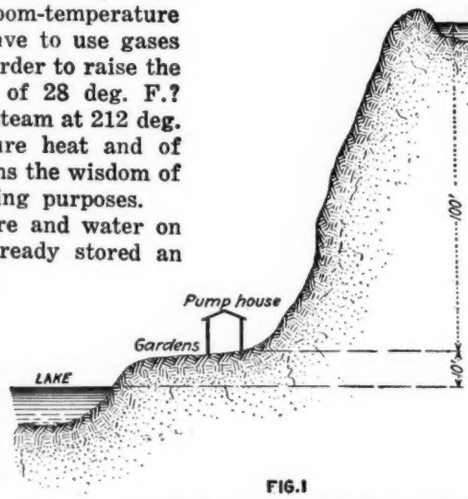


FIG. 1

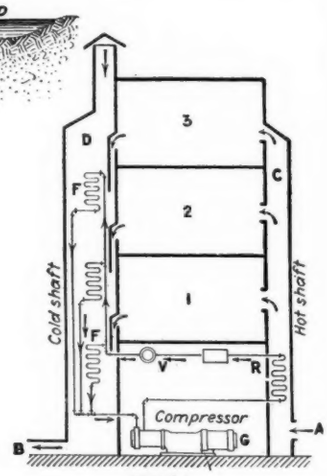


FIG. 2

FIG. 1. DIAGRAM ILLUSTRATING HYDRAULIC HEAD. FIG. 2. DIAGRAM OF BUILDING WARMED BY REFRIGERATING APPARATUS

The conditions of pumping in Fig. 1 are comparable to that. With an ideal water turbine and an ideal pump—no mechanical or fluid friction whatever—we may put the work done by the pump as equal to the work obtained from the water turbine. And since the density of the water may be considered as practically the same in both pond and lake, the volumes of water will be respectively proportional to their weights. Then to get the cubic yards of water that it will be theoretically possible to pump from the lake, we may equate, 1,000 cu.yd. $\times$ 100 ft. = cubic yards of water pumped from the lake $\times$ 10 ft. This gives $\frac{1{,}000 \times 100}{10} = 10{,}000$ cu.yd. of water pumped from the lake to the gardens when using ideal machinery.

If we take actual machinery and allow one-half of the energy in the falling water to be consumed by the

*Department of Power Engineering, Cornell University.

various quantities of friction, then the useful elevation or head of water would be only 50 ft. Hence only 5,000 cu.yd. of water would actually be pumped from the lake to the garden lands. But this would be five times the amount of water used to run the pump. This is somewhat of a gain in available water for the gardens, but even this is not all. For the water that passes through the turbine can be discharged onto the gardens, making a total of 6,000 cu.yd. of water actually made available. And it was made available not alone because there was water in the pond, but because we recognized the 100-ft. elevation or head that could be utilized to do work.

This illustration may seem far afield from the problem of warming a building, but it illustrates the fact that in order to make our great supplies of water, power or heat available, we must take into account in some form or other what is termed the elevation, or "head."

Today in order to have a desired amount of heat in the water or in the air flowing through the heating system of a building, we use the heat in fuel in much the same way as though it were the water in the pond of Fig. 1 and that it alone were desired at the level of the gardens. In short, we burn fuel, obtain intensely hot gases, then let the heat in these gases flow down hill (a temperature hill in this case) into the air or water which is to convey the heat of the fuel to the remote parts of the building. In so doing, we make available for heating the building even less heat than is in the fuel because part of the heat is lost in the cinders and up the chimney. This is much the same as if in our attempt to let the water from the pond in Fig. 1 flow down on the gardens there were a leak in the pipe or a break in the ditch which would let part of the water from the pond escape. Now, to get upon the gardens even less water than was in the pond is somewhat in contrast with obtaining six times as much water as was in the pond, which we found could be obtained by taking into account the work that could be realized from the falling water. Yet in heating our buildings today, we have just such an example of waste.

Present Heating System Unscientific

Our present system of heating buildings, it may now be stated, is unscientific in that it does not take into account the amount of work that could be done by the heat of the furnace gases nor—what means even more to us—the amount of heat that could be "pumped up" from below room temperature to a temperature somewhat above that desired in the building by utilizing this work. We attempt at present to utilize the heat in the gases to heat buildings without giving that heat a chance to do work; we simply let the heat run down hill and fail to take advantage of the excellent elevation of temperature that exists. Now the amount of high-temperature heat at our disposal is limited—it depends on our fuel supply—but the amount of low-temperature heat in the air and water around or on this earth is unlimited. Whether heat for warming buildings shall be scarce or plentiful depends on the progress of science and engineering.

It is now over sixty years since Lord Kelvin proved that the systems used for warming buildings were prodigal of heat. The cheapness of existing appliances for warming buildings was, of course, then as now the deciding consideration. Since that day we have, however, not only improved our heating systems, but have made more marvelous strides in the efficient use of heat in heat engines. At that time oil and gas engines were still in the experimental stage. Today they are the most economical heat users that engineering has so far provided for delivering power, and because of this advance former scientific proposals are now in a fairer way to become commercial realities. We are turning today to mechanical means; that is, by the use of refrigerating machines, to cool our large hotels and auditoriums. That these same heat pumps, for that is what refrigerating machines are, could, if made to withstand a higher pressure, be used for heating our hotels and large dwellings, is not common knowledge. It was Lord Kelvin who first explained that this is the scientific way to heat buildings.

"Pumping Up" Low Temperature Heat

In Fig. 1 it is shown that an abundance of water was made available by recognizing the possibilities of the 100-ft. head and its application to do work and to operate a pump. Furthermore, the quantities of heat about us which are necessary to keep the tons of air and water in their fluid state and at a temperature not greatly below that which we commonly desire in our homes have already been referred to. The problem, then, becomes one of applying energy and machinery to this great store of low-temperature heat and "pumping it up" to that level at which we desire it. The "head" to be pumped against in this case, is not one of feet of elevation, as when pumping water, but a "head" in degrees of temperature, measured with a thermometer.

But how can we pump heat? Easily enough. We handle heat by applying the same idea that we use in elevating coal, grain or crushed stone: we use a conveyor and handle the heat fast enough to prevent appreciable leakage. The most evident heat conveyors that we are all acquainted with are the air and the water of heating systems for buildings. Our choice here as the conveyor will, however, be ammonia.

Of mechanical apparatus we should have two pieces similar in purpose to those we had in Fig. 1: (1) A turbine or engine to utilize high-temperature heat; (2) a pump to elevate low-temperature heat. And just as we used water to pump water, we can likewise use heat to pump heat, but because we are pumping heat, a somewhat unfamiliar process, we must not let the greater magnitude of heat discharged by the pump over that supplied to run the pump—which conditions our problem will finally show—mislead us into thinking we are attempting the unreasonable. The heat discharged is a measure of the capacity of the heat pump, and the capacity of a heat pump to pump heat must not be confused with heat-engine efficiency in the use of heat.

Those buildings that are equipped with refrigerating machines have already both the required "turbine" and the "heat pump." For, as stated before, the refrigerating machine is a heat pump. But while the "turbine" (engine) could probably meet the necessary load without requiring much change, the "pump" (compressor) might not be capable of safely carrying the necessary pressure. We shall, however, since heat pumps are as yet too costly to be installed for cold-weather use only, assume that a refrigerating machine is already installed for summer use, which is strong enough for the pressures required when the machine is turned over to serve as a warming device in cool weather.

In Fig. 2 a section of a building of several stories is shown diagrammatically. Refinements of design and equipment will not be considered. The purpose will be to show how practicable the heat pump may be, under

some conditions, for warming a building. Considering first the path of the air, fresh air enters the duct *A* and is heated by coils *E*. The warm air rises in the shaft *C* and enters rooms 1, 2, 3, through the ducts shown. The spent air from the rooms then passes through the ducts provided into air shaft *D*, where it mingles with a stream of atmospheric air that also enters through a suitable duct. In shaft *D* are other coils *F* colder than the mixture of spent air and atmosphere, so that owing to their cooling effect it will, acting as a reversed chimney, serve the double purpose of helping to withdraw the spent air from the rooms and of providing a flow of air across the coils *F* whose function is to absorb low-temperature heat from that air.

Consider next the mechanical operation of the heat pump. Liquid ammonia discharged from the receiver *R* through the expansion valve *V* becomes in part a gas and suffers a drop in temperature. In the coils *F* the cold mixture of liquid and gaseous ammonia takes in heat from the air in the air shaft *D*, and the ammonia may become wholly gasified. Next, the compressor *G* draws in a cylinderful of the ammonia gas and compresses it. But the work of compressing the gas raises its temperature, and we compress it enough to get the temperature desired in the coils *E*, which in turn give up the high-temperature heat of the ammonia to the fresh air entering the shaft *C* by way of the duct *A*, and this chills the ammonia, which condenses and returns to the receiver *R* as a liquid. For simplicity, the double system of coils by which, for the sake of safety, the ammonia would be made first to heat water, which in turn would heat the air, is not shown, nor is any system of radiators which could take the place of the heating done upon the air in shaft *C*.

Minor Heat Leakages Ignored

Coming next to the path of the heat we ignore minor heat leakages. Low-temperature heat in the cold-air shaft *D* is picked up by the cold ammonia (the conveyor) and is carried over to air shaft *C* with the progress of the ammonia. On the way over, however, the quantity of heat in the ammonia is increased, for the compressor does work upon it, and just as a gas or a vapor, when it expands behind a piston, converts into work some of the heat it contains, the reverse, or a conversion of work into heat, which heat goes to increase the heat already in the ammonia, takes place when compression occurs. On the way over, then, the compressor increases the pressure, the temperature and the heat content of the ammonia, and the amount of heat thus added to the ammonia will be the equivalent of the foot-pounds of work that the engine delivers to the compressor end of the machine. If, then, we let *Q* stand for "quantity of heat," we shall have, when the ammonia arrives in the hot coils, an amount of heat available for discharge to the fresh air of shaft *C* equal to the *Q* absorbed in shaft *D* plus the *Q* added by the work of the compressor. This is comparable to the operation in Fig. 1, where the water drawn up from the lake plus the water fed to the turbine become as a combined quantity available for watering the gardens.

The compressor has now accomplished two things—it has increased by a definite amount the heat in the ammonia over the amount that was absorbed from the cold air, and it has raised the pressure and temperature of the ammonia till, as a result, it is possible for both that *Q* obtained from the cold air and that *Q* added in the compressor to flow into the warm air shaft. This is a most happy result for our undertaking. The proof that this result is possible requires the use of diagrams which will not be introduced here. Let it suffice, therefore, to recall the results in Fig. 1, where the lake water plus the water that does the work are eventually combined and discharged upon the land. Reviewing the path of the heat, low-temperature heat is absorbed in shaft *D*, this heat, while being conveyed across to shaft *C*, is increased and also raised in temperature by the compressor; then what has now become high-temperature heat is discharged into shaft *C*. The ammonia is condensed and returns by way of the receiver and expansion valve to repeat its conveying functions.

What, now, is the magnitude of the amount of heat given to the air in shaft *C* compared with the heat supplied to make that warming possible? This will be shown later. For the present assume the compressor is driven by an oil engine (see Fig. 3.) If, now, in our chosen installation the number of heat units in the fuel oil supplied to the engine—in order that the engine may impart to the compressor work enough to compress the ammonia—be less than the amount of heat discharged to the fresh air in shaft *C*, then we shall have a system that discharges more heat than we put into it. This is something a house furnace cannot do.

Perpetual Motion Not Attempted

Going back to the problem of getting water upon the gardens, perpetual motion was not obtained when more water was delivered upon the gardens than was used to pump that water, nor was any attempt made to get the water fed to the turbine to return to the pond. To have tried to do so would have been an attempt at perpetual motion. What was really done was to take a small quantity of water from the pond, let it do work and then allow it to remain at a greatly lower level. The same reasoning applies to our use of heat in the heat pump; we have gained in the quantity of heat at our disposal for heating purposes, but have sacrificed, for part of that heat, an enormous elevation of temperature. We have raised some heat from perhaps 35 deg. to 125 deg. F., but have also let down other heat in the cylinder of the oil engine from perhaps 2,500 deg. to 900 deg. F.

Because the heat pump involves a "conveyor" (the ammonia) the operations are not so direct as with the water turbine and its pump. For example, in the water turbine all the water supplied to it goes to join the water pumped; in the heat turbine (the oil engine) all the heat supplied to it does not go to join the heat "pumped up," but owing to the limitations of heat engines most of the heat in the fuel supplied to the engine goes finally out in the exhaust and jacket water. In our job, however, much of this "waste heat" could be used in air shaft *C* to help boost the temperature. Were the heat engine as efficient in converting potential energy into work as is the water turbine, our problem would work out much better than it does.

A Specific Problem Explained

Our undertaking has now narrowed down to running the ammonia compressor at a high enough discharge pressure to give condensing water sufficiently hot to warm the fresh-air supply. It remains to show by calculation whether it would be more profitable from the point of view of heat economy to operate the refrigerating machine instead of a boiler or furnace in order to warm the building in cool weather.

Let us consider first a cool, rather than a cold-weather problem; the atmosphere to be not below 40 deg. F., and that the mixture of spent and fresh air will leave the shaft *D* at a temperature not below 35 deg. F. We shall assume the following data and conditions: For simplicity in calculations we shall let the oil engine deliver to the compressor one horsepower-hour, or the equivalent in work of 2,545 B.t.u. per hour.

We shall ignore jacket effect for the compressor and consider no pre-cooling of the ammonia. These are two conditions unfavorable to our problem.

We shall, further, ignore the heat leakage in connections between pieces of apparatus and shall assume the ammonia enters the compressor in dry saturated state.

Heat value of fuel oil, 18,200 B.t.u. per pound.

Fuel consumption of oil engine per brake horsepower-hour, 0.5 lb.

Suction pressure in ammonia compressor, 53 lb. absolute; corresponding temperature in cold coils, 25 deg. F.

Discharge pressure in ammonia compressor 312 lb. absolute; corresponding saturation temperature in hot coils (condenser), 125 deg. F.

We desire to find the ratio of the heat supplied by the heat pump to the heat supplied by a boiler and furnace. The same amount of fuel oil to be used in both cases, and the heat to be delivered to the hot coils in shaft *C*.

Referring to Fig. 3, the engine is supplied with 0.5 × 18,200, or 9,100 B.t.u. per brake horsepower-hour. Of

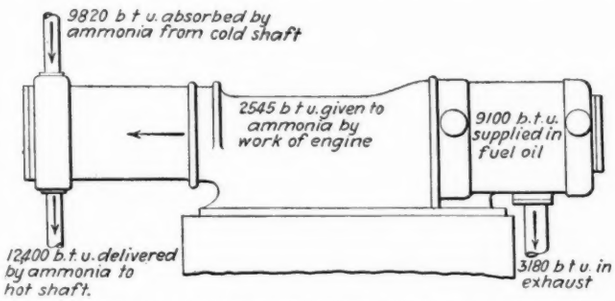

9820 b t u. absorbed by ammonia from cold shaft
2545 b t u. given to ammonia by work of engine
9100 b.t.u. supplied in fuel oil
12400 b.t.u. delivered by ammonia to hot shaft.
3180 b t u. in exhaust

FIG. 3. DIAGRAMMATIC ILLUSTRATION OF HEAT UNIT TRANSFERENCE BY AMMONIA COMPRESSOR

these 9,100 B.t.u., say 35 per cent or 3,180 B.t.u., go out in the exhaust. This "waste heat" could be utilized to heat air in shaft *C*. Other 2,545 B.t.u., the equivalent of one horsepower-hour, go to do work at the compressor and upon the ammonia. These 2,545 B.t.u., together with the B.t.u. absorbed from the cold coils will give the number of B.t.u. supplied to the hot coils by the heat pump when 0.5 lb. of fuel oil is used.

But how many B.t.u. are absorbed from the cold coils when 2,545 B.t.u. are supplied as work done on the ammonia? For the answer we must refer to tables and chart of ammonia properties (see "Mark's Handbook," pages 333 to 335).

From the handbook we find that (per pound of ammonia circulated) the amount of heat absorbed from the cold coils in shaft *D* will, for the conditions chosen, be 436 B.t.u. We further find that the amount of work done on one pound of ammonia while passing through the compressor will be equivalent to 113 B.t.u. Now these two quantities combined, or 549 B.t.u., is the amount of heat supplied to the hot coils for every pound of ammonia circulated. Hence, if 549 B.t.u. are discharged into the hot coils every time that 113 B.t.u. are added to the ammonia because of the work done on it in the compressor, it follows that the number of B.t.u. discharged into the hot coils when 2,545 B.t.u. are supplied as work upon the ammonia, will be $2{,}545 \times \frac{549}{113} = 12{,}400$ B.t.u. Using the same quantity of oil under a boiler and allowing a boiler and furnace efficiency of 75 per cent, the heat that could be supplied to the coils in shaft *C* would be $0.5 \times 18{,}200 \times 0.75 = 6{,}820$ B.t.u.

From these values we get the ratio of heat supplied by heat pump to heat supplied by boiler and furnace as $\frac{12{,}400}{6{,}820} = 1.82$. With the heat of the exhaust fully utilized, the ratio becomes $\frac{15{,}580}{6{,}820} = 2.28$.

Were it necessary to have the suction temperature zero deg. F., then the heat pump would deliver but 9,750 B.t.u. when 0.5 lb. of fuel oil was supplied, and the ratio becomes only 1.43. In this case, however, a large amount of precooling could be obtained, which would boost the value of the ratio, as would also the jacket effect, which would be essential here in order to keep down an extreme amount of superheat. Further, we might have to resort to mechanical means for defrosting the coils in shaft *D*.

Operating Conditions Depend on Price of Fuel

The commercially permissible operating conditions depend, of course, on the price of fuel, since that together with the hours of operation determine the allowable investment in heating surfaces. The ideal condition would seemingly be to make ice while pumping heat, but the output of ice would probably be too vast for storage capacity.

With the compressor driven by electric motor and with the compressor piston receiving 68 per cent of the energy supplied to the motor, the heat pump would deliver, under conditions of the original problem, 11,330 B.t.u. to the coils per kilowatt-hour supplied to the motor. One kilowatt-hour converted directly into heat would give but 3,412 B.t.u. Dividing 11,330 by 3,412 gives a ratio of 3.32. This value, of course, takes into account no steam-electric plant losses and is worth considering only in connection with hydro-electric power.

The manner in which the improvement in oil-engine economy advances the possibilities of the heat pump can be shown if we assume that for a steam-driven heat pump three pounds of coal. with 13,200 B.t.u. per pound, would be needed per brake horsepower-hour of engine. These three pounds of coal burned under a boiler, with a boiler and grate efficiency of 65 per cent, could deliver to the coils $3 \times 13{,}200 \times 0.65 = 25{,}700$ B.t.u. Now for the conditions of the original problem 12,400 B.t.u. are delivered by the heat pump per brake horsepower-hour supplied. This gives a ratio of $12{,}400 \div 25{,}700 = 0.48$ only. Were the heat pump steam-driven, the steam might better be used direct from boiler to coils.

The temperature of 125 deg. F. selected for the hot coils would call for the use of extensive heating surface. Higher temperatures are obtainable, of course, if we submit to the increasingly higher pressures and to the smaller ratio which corresponds with an increase in the work required. Without tabulating more values of the ratio, it may be stated that the work required increases at a slightly diminishing rate as higher temperatures in the hot coil are selected.

Development of the Stirling Boiler

Recent Modifications Making for Standardization of Classes, Greater Accessibility, Elimination of Priming and Improved Setting

AS ORIGINALLY designed by Allan Stirling and introduced in 1889 by the International Boiler Co., Ltd., of New York, the Stirling boiler consisted of a single upper, or steam drum, and a mud drum. This boiler, as described in the patent specifications, was made up of a steam drum rectangular in shape, the top and bottom plates of which were stayed by staybolts screwed into the bottom sheet, the upper ends being provided with screw threads which extended through the upper sheet and were held in place by nuts. Water tubes of various lengths were expanded into the steam drum and formed drop tubes closed at the lower ends. The mud drum was cylindrical and was connected to the steam drum by two downcomers which were embedded in the side wall. Front and side views of this boiler as originally patented are shown in Figs. 2 and 3, which clearly indicate the general design. Note in Fig. 3 the reverse arch. The first boiler of this general design built, was installed at Westville, Nova Scotia. While the general features of the patent were retained in the boiler as actually built, there were several modifications in detail. The boiler as installed is shown in Fig. 4. In this unit there was one row of tubes that was not closed, the tubes in this row being connected to both the front and the rear of the steam drum. This row acted as a support for a baffle roof that served as a furnace arch and a front baffle. The mud drum was below the grate and connected to the steam drum by a single row of tubes exposed to the products of combustion. The manhole was on the top of the steam drum.

When the boiler was placed in service, trouble developed through the burning of tubes at the bottom ends. The baffle, as shown in Fig. 4, was one of the schemes tried out to prevent the burning of tubes. It was extremely difficult to remove tubes as the staybolts in the steam drum had to be taken out first and unless the tube to be removed came directly under the manhole plate, other tubes than that to be replaced had to be taken out. As far as the records show, the Westville boiler was the only installation with a rectangular steam drum.

The first modification was to increase the number of drums, making two upper, or steam, drums and a mud drum interconnected by bent tubes 2 in. in diameter. One of the designs of this three-drum Stirling boiler is illustrated in Fig. 5. This boiler, while crudely constructed, demonstrated that the design was such as to give great possibility for development, and the Stirling Co. was formed in 1890 and purchased the interests of the International Boiler Co., Limited.

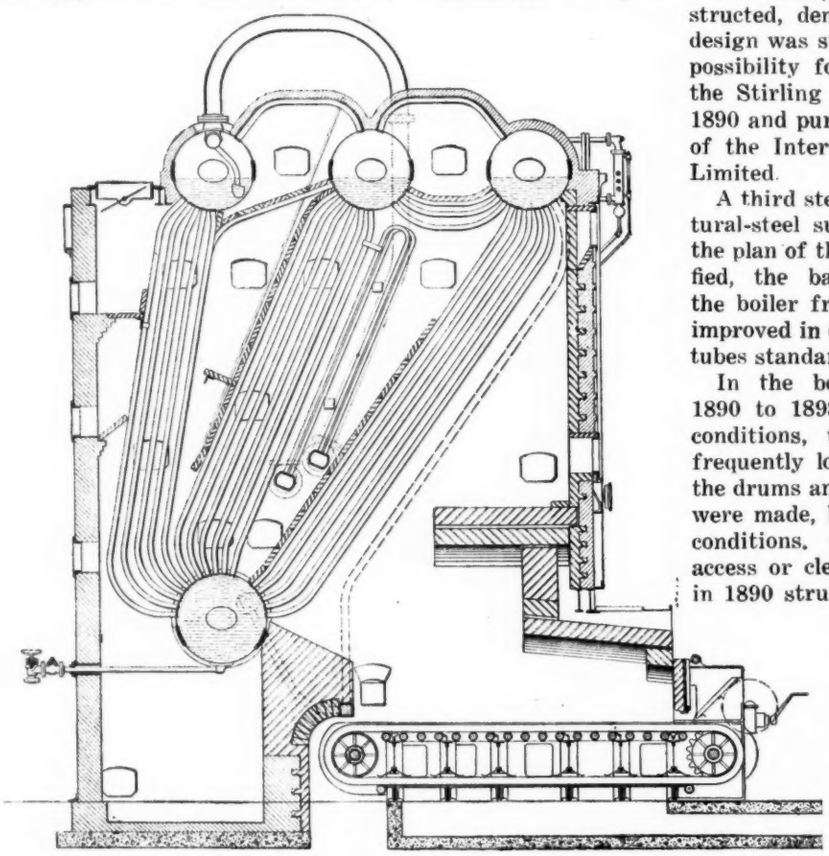


FIG. 1. SECTION THROUGH ONE OF THE NEW CLASSES

A third steam drum and structural-steel supports were added, the plan of the setting was modified, the baffling standardized, the boiler fronts elaborated and improved in construction and the tubes standardized at 3½ in.

In the boilers offered from 1890 to 1898, because of space conditions, the manholes were frequently located on the top of the drums and many installations were made, because of the same conditions, practically without access or cleaning doors. While in 1890 structural-steel supports were added, there were a number of contracts made where the boilers were carried on saddles under the mud drum and on columns in the front wall to which lugs on the forward or steam drum were riveted. The Stirling boiler, as designed in 1890, was marketed with but little change up to 1898. Although in general it gave reasonably satisfactory service during that period, there were numerous features of the design that were faulty in the extreme. The 3½-in. tubes were spaced on 6-in. centers, which made it necessary in order to remove any inner tube of a bank to cut out the outer tubes for such removal. The water column was attached to the front steam drum, in which position it gave an erroneous water-level reading.

About 1898 the water columns were connected to the center drum, in which location a true water level was indicated. The tubes were spaced with alternate wide and narrow spacing, making it possible to remove any tube without disturbing any other tube. Moreover, the practical development of turbine tube cleaners made

possible the proper internal cleaning of the boiler tubes.

At that time boilers were sold very generally to meet a specific set of space conditions; the result of that practice was the evolution of a number of boilers of approximately the same heating surface, but with radically different over-all dimensions, the different units coming to be known as classes. The builders of the Stirling boiler, while maintaining the same features of construction and design in the different classes, apparently paid no attention to the method of variation between classes, the result being a series of classes having little in common as to relative drum locations, tube inclinations, tube lengths or ratios of grate surface or heating surface. Fig. 6 shows in outline fourteen of the classes that were developed under this system superimposed one over the other and indicates the wide variation in the features listed.

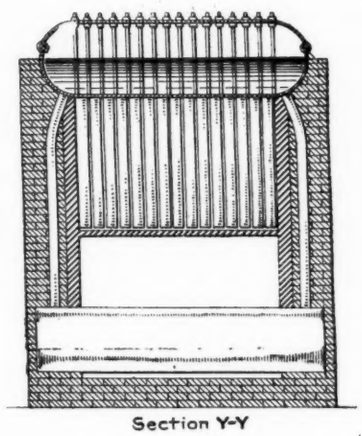


FIG. 2. FRONT VIEW OF ORIGINAL BOILER

During the last fifteen years there have been numerous changes made in the Stirling boiler. In certain instances these have been made to meet special

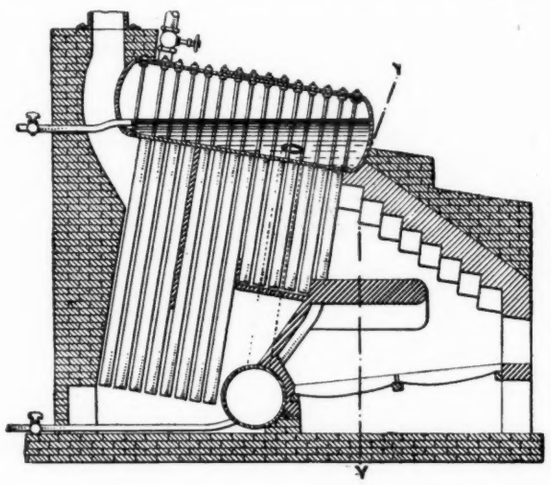


FIG. 3. SIDE VIEW OF ORIGINAL BOILER

and unusual operating conditions, and others have been the result of improvements in detail of design and construction.

The principal improvements in design over the boiler hitherto offered are as follows:

First: All steam drums are now placed on the same level, the steam being taken from the rear steam drum.

The steam and water circulating tubes which come between the drums are designed and proportioned on the basis of numerous tests made under service conditions, the necessary degree of restriction to the flow of steam and water which they give being such that highly concentrated water can be handled without involving priming difficulties.

At the higher capacities the length of time necessary for the degree of concentration of salts in the water within the boiler to build up to an objectionable point was correspondingly diminished, and some feed waters that could be readily handled at low capacities began to

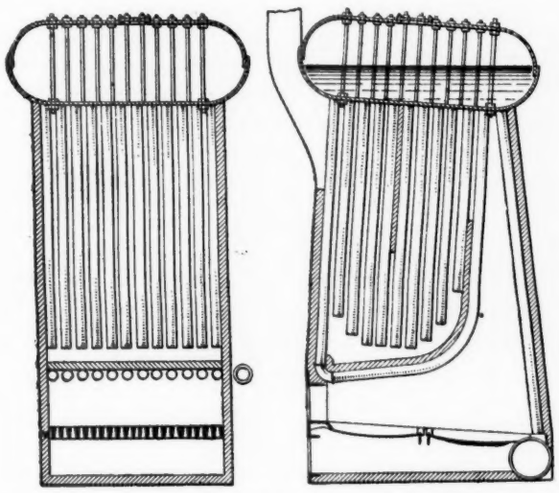


FIG. 4. BOILER AS INSTALLED AT WESTVILLE

give trouble through priming unless the amount of blowdown was excessive.

Numerous experiments were made to overcome priming troubles under the special conditions encountered, with the result that in the redesigned Stirling boiler the steam is taken from the rear drum which is raised to the level of the center steam drum.

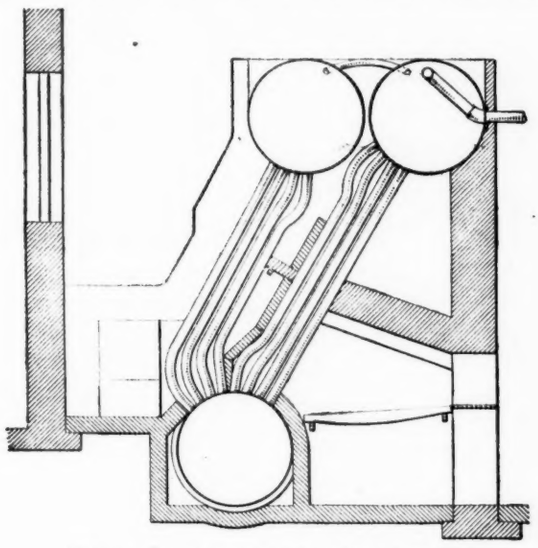


FIG. 5. EARLY THREE-DRUM DESIGN

This construction enables a degree of concentration to be carried in the redesigned boiler that would undoubtedly lead, in certain instances, to priming with a center-drum steam outlet. The change has been made, not with any idea of advocating higher degrees of concentration than are now usual, but in order to take care of conditions under which, because of feed-water conditions, concentration unavoidably builds up rapidly.

Second: Protection of the rear steam drum is given by a baffle carried on the front tube of the rear bank, which is expanded into the center drum.

Third: The arrangement of the tubes circumferentially on the mud drum is such as to give a larger superheater chamber. In the earlier design the tubes were spaced equi-distant around the mud drum, there being no space between the rear tube of the front bank and the front tube of the middle bank. This led to a superheater chamber excessively cramped at the lower end, making it difficult and uncomfortable to get at the superheater headers. In the redesigned boiler there is a space left between the rear tube of the front bank and the front tube of the middle bank equal to the space hitherto occupied by two tubes. This permits a greater amount of superheating surface for higher superheat than hitherto obtainable and gives a much greater ease of access to the superheater headers and handhole caps.

Fourth: In stoker-fired work, except in the case of stokers of a design that permits of carrying the front boiler wall, this wall is carried on supporting members

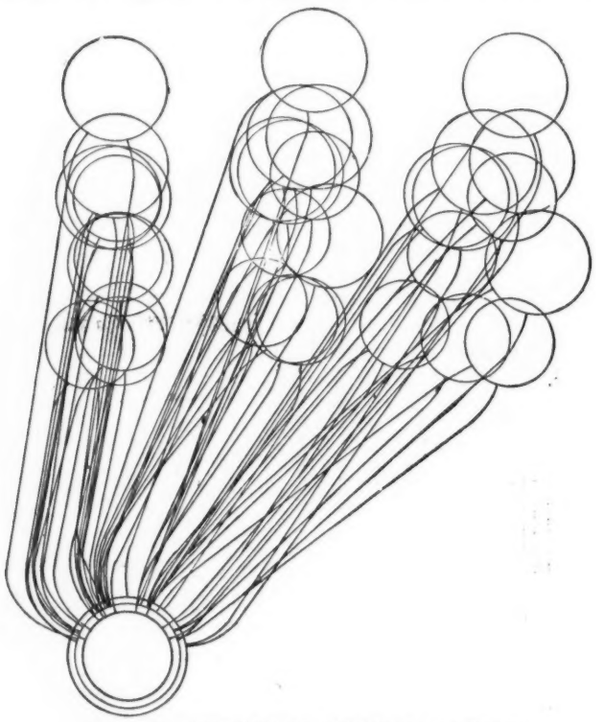


FIG. 6. OUTLINE OF FORMER CLASSES

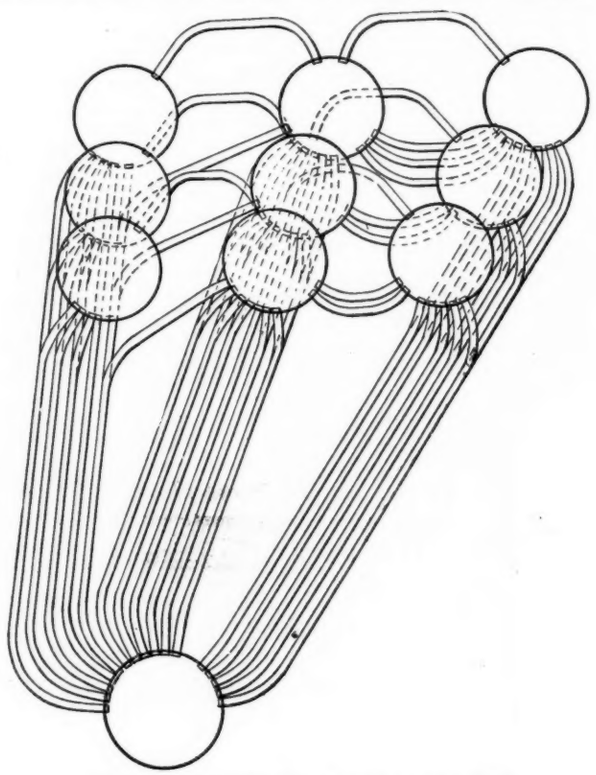


FIG. 7. OUTLINE OF PRESENT CLASSES

furnished as part of the standard boiler equipment. Where this front wall is so carried, a slip joint between the front boiler wall and that portion of the wall carried on the stoker is used. These features not only definitely fix the responsibility of carrying the front boiler wall, but give a front wall construction that may be repaired without taking down the entire wall.

Fifth: Where the size of the boiler wall is such as to made it advisable, the use of bonding tile with properly designed supporting members is standard construction in the front wall. This construction, as proved in operation, is successful in overcoming the tendency of the front wall to spring inward. This construction is used in side walls where necessary.

Sixth: In the earlier designs, where battery settings were installed, a three-legged center support was standard in the battery wall. In the redesigned boiler the center support has but two vertical members, doing away with this objection.

Seventh: In battery settings special means of access for inspection of the inside mud drum heads is standard in the redesigned boiler.

The studies that have led to the redesigning of the Stirling boiler naturally led to a consideration of the variation between classes and sizes of boilers. This has resulted in an entirely new classification in which the variation between the classes and sizes is simple, logical and progressive. The method in variation between classes is clearly indicated by Fig. 7. Compare this with classes hitherto used, as shown in Fig. 6.

While the purchaser of steam boilers is not primarily interested in methods of manufacture provided proper construction methods are followed, it is, however, the purchaser who ultimately receives the benefit of any improvements in manufacturing methods. The reclassification will, undoubtedly, lead to reduction in manufacturing cost. Comparison between classes as hitherto standard and as now reclassified, leaves no question as to which leads to simplicity of manufacture.

The reduction in manufacturing cost that will result from the reclassification will come about through a reduction in inventory of material that must be carried; in the number of standards in use; the greater number of parts applicable to the large production of the boilers built; the interchangeability of such parts; the manufacturers' ability to build more nearly for stock; an increase in flexibility of output and quicker shipments.

While the manufacturer of this boiler will offer previous standards to complete plants in which such standards were installed, it is the intention to offer the redesigned and reclassified boilers for all new work.

A side view of one of the new Stirling classes, with superheater and chain-grate stoker, is shown in Fig. 1.

EDITORIALS

Making an Investment Pay

IN EVERY great industrial center, in every hamlet, wherever business is done, there executives are out cost cutting. It is not overstating it to say that in every American industrial plant the management has already surprised itself on what it has so far accomplished in this pursuit. And the end of the chase is not yet in sight for most managements. Business houses, realizing the awakening of the spirit of frugality and thrift, make economy the dominant sales appeal, knowing it is now the strongest one to arouse interest.

No less for the power-plant man than for the president of his company is this a time for getting greater return on the investment and making the plant's services cost less. This is part of readjustment. Idle factories cost everybody a lot of money. Overhead's appetite is never satisfied, and when there is less to feed it, it demands proportionally more.

But it must be borne in mind that a part of cost-cutting may often be the spending of money, investing it in equipment that will return the cost long before the equipment has reached the end of its useful life. Money is now hard to get. Every management knows there are many things that it would be worth while to buy. Managements now have more time to consider such forms of investment; they are in better mood for such consideration than they have been in many a year. It may be a long time before the investment can be made, but it is during times like the present that propositions are being decided for or against.

As for companies that have economy-producing equipment to sell, this is no time for exaggerated claims and great hurrah. Those who can produce the records of outstanding performances and explain the "why" of their claims to superiority will be listened to. The power-plant engineer knows a thing or two, and the salesman or advertisment must be able to "put over" the idea and deliver the goods.

Cutting It Down

WE USED to call it, when we were writing and wished to be precise and formal, "The Rankine Efficiency Ratio." In ordinary conversation and between friends it was just the plain "Rankine Efficiency" of the engine or turbine or whatever else that we were talking about.

And then came the Committee on Definitions and Values of the American Society of Mechanical Engineers and recommended that, in order to avoid contention between the friends of Rankine and Clausius as to credit for the exposition of the cycle bearing both of their names, the Rankine be eliminated, reducing it to "The Efficiency Ratio."

And now comes Mr. Charles H. Smoot, member of another of the code revision committees of the society, calling attention to the fact that the denominators of the efficiencies the ratio of which was taken as a definition of the quantity in question, are identical and cancel out, leaving, not an efficiency ratio at all, but a common efficiency, a simple input-output relation. The word ratio is therefore ridiculous, misleading and redundant and should be cut out, leaving it "The Efficiency."

All of which is reminiscent of the fisherman who, having attained to a condition of comparative affluence by selling fish out of a net stretched between poles on the beach of a fashionable resort, concluded that he ought to have a sign. And one morning there appeared above the netful of squirming, shining sea-food a banner bearing the announcement, "Fresh Fish for Sale Here." The first customer, an old resident, read the sign critically and wanted to know what he had put the "Here" on it for. "Where would anybody naturally suppose they was for sale? In Kalamazoo?" And the merchant saw that he had erred and scratched out the word here.

And then came a little soubrette in a sunbonnet with a market basket on her arm; and she made fun of his use of the word fresh. Could not anybody see that they were fresh? Most of them were actually alive. And he conceded that she had reason—and scratched out the word fresh.

And then came one who read "Fish for Sale" and asked, "Why do you need the 'For Sale' on there? Afraid somebody will think you are giving them away?" And there seemed to be something in that, and the "For Sale" came off.

And then somebody asked him if he had them labeled "Fish" so that people would not mistake them for bologna sausage, and he took down the sign and concluded to allow his wriggling wares to speak for themselves.

Direct-Current Machinery with Compensating Windings

EVERY operating engineer feels that when he keeps his direct-current machinery in such condition that it operates with sparkless commutation, about one- hundred per cent service is obtained. Sparking at the brushes of direct-current machinery has always been an operating man's nightmare, even to a greater extent than preventing leaks in steam lines. However, by proper designs both have in modern equipment been reduced well down toward a minimum.

In the armature coils under commutation a very complicated action is going on all the time the machine is in operation. During the time required for a commutator segment to pass a brush, the current in the coil must decrease from normal value to zero, reverse and increase to normal value in the opposite direction. This period may be less than one-thousandth of a second. Consequently, to make this reversal without causing sparking, some means must be provided to set up a voltage in the coil to assist in the reversal. In the early type of machines this was accomplished by shifting the brushes so as to bring the coil under commutation into a field of

correct value and polarity. But with a varying load this commutating field would be varied, owing to the armature poles cross-magnetizing the main poles. To maintain a field of correct value and direction at all loads, interpoles were introduced, and this was a big advance toward obtaining a sparkless commutation, although it did not remove the major cause of poor commutation—armature reaction.

As pointed out in the article, "Operation of Direct-Current Machinery with Compensating Windings," by H. M. Phillips, in this issue, interpoles may even increase armature reaction, by pushing the armature poles around nearer to the main poles. In doing so potentials may be built up in certain of the armature coils, which will cause flashovers. For this reason the interpole machine has been found unsatisfactory for very severe conditions of operation, especially when the motor is quickly reversed from full load in one direction of rotation to full load in the opposite direction. For such applications the armature reaction must be eliminated, and this can be done only by a compensating winding such as described by Mr. Phillips.

Although compensating windings were introduced in the early development of direct-current machinery, their general adoption has been slow. This was also true of the interpole machine, and it has been only within the last ten years that the adoption of this design has become general. Today it is considered almost essential to satisfactory direct-current machinery operation. However, machines with compensating winding no doubt will find a more general use, as the requirements of motor drive become more exacting, since at the present time these windings have made possible electrical-machinery applications which otherwise would be practically impossible.

The Heating System

A LARGE portion of the available coal supply is consumed in the heating of buildings. While the heating plant is far more economical than is a power-generating system, nevertheless a direct loss of thirty to fifty per cent of the heat value in the coal occurs in the boiler room. Any method by which this loss can be avoided is of vital interest even though its successful application is not immediately possible.

On another page Robertson Matthews outlines a heating system proposed many years ago by Lord Kelvin. In this system advantage is taken of the immense store of low-temperature heat which is contained in the atmosphere even during the cold months. Reversing the usual refrigeration cycle, Mr. Matthews would take heat from the atmosphere and force it into the storage room, in this case the building to be heated.

While the author has disregarded many of the small losses incident to the operation of a refrigeration system, the calculations he cites prove that the plan cannot be termed impossible. By raising the temperature of the evaporating passage, which could be achieved by using a greater proportion of the spent air from the building, the percentage of heat supplied by the compressor would be reduced. Lowering the temperature of the discharge gases might necessitate the employment of a larger compressor, but would increase the system's efficiency.

The one objection that is raised in the article is that the pressure placed on the compressor and discharge system is excessive. While it is somewhat above refrigeration practice, a large number of air compressors are in successful operation under pressures as high as one thousand pounds per square inch.

There is no actual obstacle to the use of this heating system in combination with the refrigeration system. In the colder months, when the demand for refrigeration is light, nothing prevents the use of part of the heating-compressor capacity to secure a refrigerating effect at a lower suction pressure than the heat system causes.

While the heating system outlined is in no danger of immediate adoption, engineers should study the merits and demerits of the plan.

Is It Chloroform or Smelling Salts?

THE Secretary of War has stated his willingness to ask Congress for further appropriations sufficient to complete the Muscle Shoals power project on condition that some private enterprise will exhibit sufficient faith in the project to agree to take over the power plant when completed, presumably on terms that will give to the Government some return upon its investment. It is worth while to consider just what this means.

The total investment in the Muscle Shoals power development, if completed, would, it is estimated, be in the neighborhood of fifty million dollars. Presumably the Government would want at least six per cent on this money to care for the interest and amortization without any thought of profit. If the project could be counted upon for a continuous development of one hundred thousand horsepower, a six per cent return would mean thirty dollars per horsepower-year as a capital charge payable to the Government. Whether terms more favorable than this could be arranged, of course, is problematical and what additional charges would be involved in the maintenance and operation of the project is equally uncertain, but it is clear that this project still has a chance to go forward only if the Secretary of War can be assured of industrial confidence in the plan.

Violent means to destroy the project have been frequent during its life as one of the favorite political footballs of Congress. It will be interesting to learn from further developments whether this new policy announced by the Secretary of War proves to be simply a more humane system of killing the project or whether it will be found to be a stimulant to revive what seemed to be a fainting undertaking.

"There is danger in an organization chart—danger that it may be mistaken for an organization," says Arthur D. Little, chemical engineer. The same danger exists in every power plant where there are instruments of various kinds for securing efficiency—danger that they may be mistaken for efficiency. The most elaborate system of instruments is worthless without intelligent, whole-hearted co-operation between those who specify them and those who operate them. To install good equipment is but half the battle—it is fully as important to see that it is properly used and that the results are intelligently interpreted and acted upon.

In the issue of May 3 the boilers and auxiliary equipment of Colfax Station will be described—a mine-mouth power plant designed for an ultimate capacity of three hundred thousand kilowatts.

CORRESPONDENCE

Which Way Are You Going?

The readjustment now going on throughout the country marks the parting of the ways for the engineering fraternity. During the war any engineer could get a job, even if he went on crutches or in a wheel chair to apply for it, especially in the license states.

Today the supply exceeds the demand and only the better men are being retained, while the others go to the scrap heap. In Massachusetts the old-established precedent of former years has been violated, especially in the textile centers. In years past it was customary, during shutdowns due to poor business, to lay off the firemen and let the assistant engineers take their place in the boiler room to maintain heat and steam for fire protection. During the present business depression the tables have been turned and the firemen have remained, while the assistants have been laid off or discharged outright. I can see but two reasons for this action. First, many manufacturers are discharging their help so as to be able to hire them over at less money instead of starting friction by making a reduction. This the textile men would not do, as they have not reached that stage of diplomacy, but slash wages without fear or favor. Second, the existing conditions give the employer an excellent opportunity to eliminate the dead wood from their engine rooms and replace it with the many live wires that have kept up with the times.

Now is the time for each to make an impartial self-analysis. I find many men that have grown rusty and behind the times to the extent that they freely admit it, but mental inertia prevents them from slacking off their lethargy and making a spurt that will place them in positions where their long years of service entitle them to be.

Some men excuse themselves by saying that they are too old to learn; others claim that it is of no use, nobody wants an old man for an engineer. The old man has greater opportunities today than ever before if he has kept abreast of the times, and some of the hardest-working students I know through a very broad acquaintance are men from 50 to 65 years old who have been in the engineering business for years. If it pays men who are over the peak, why should not the younger generation profit by their example and improve their opportunities to learn while they are able to get the most in the shortest time?

Thousands are soothing themselves with the wail that steam engineering will soon be a lost art, owing to the encroachments of the central station. It is true that many of our smaller and more wasteful steam plants are being done away with, but the plant that furnishes steam for process work or has a high demand for exhaust steam is here to stay. The central stations must be manned and, in the writer's opinion, they cannot compete with many large, efficiently managed private plants. Consequently, while the number of steam plants may decrease, the aggregate horsepower will increase, the standard to be maintained will be elevated, and the engineer will become a professional man with a salary in keeping with his standing.

Now is the time to choose your road. Will you study and work hard with the assurance of being able to do your work at a desk with a salary you can be proud of, or will you choose the path of least resistance, floating along with the tide and finishing as an oiler, fireman or wiper and general utility man? H. K. WILSON.

New Bedford, Mass.

Fitting Oil-Engine Piston Rings

In your editorial comment on the communication of P. P. Telaty (*Power*, March 8, page 400), you recommended filing and scraping a ring to a fit. While this may be the practice in repair shops, it is a sign that the ring has not been machined properly in the first place. If the ring is drawn together by means of a wire or a suitable clamp and then turned by being held between suitable clamps or plates, it will fit the cylinder when in place. The best practice is to turn the periphery of the ring with a diamond-point tool, using a fine feed, about 100 per inch. Such a ring will "find its seat" after about one hour of running.

The only time in which fitting the ring by hand is justified is when the bore of the cylinder is worn "out of round." In that case the ring is placed in a dummy piston and spotted by drawing it back and forth in a lampblacked portion of the cylinder. While I am aware that this practice is followed in certain shops in new work, it is not good practice. Usually, such a shop follows similar methods in fitting other parts of the engine.

I have in mind a certain shop in California, where rings were fitted in this way. No two of their engines were precisely alike, and parts were not interchangeable. It was necessary to send a man from the shop to make any repair that required the fitting of a new part. E. W. ROBERTS.

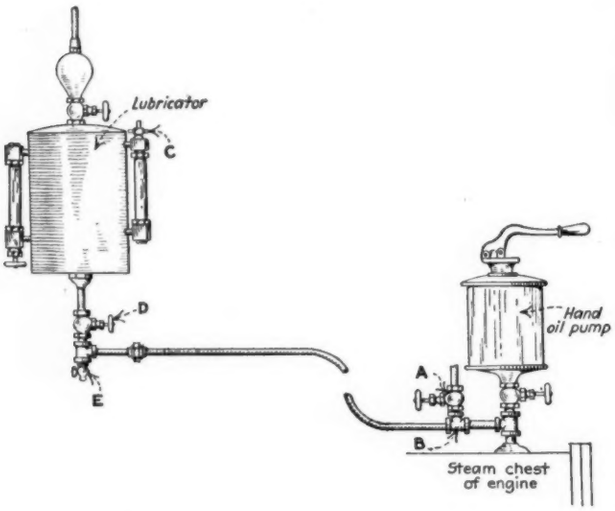
Cincinnati, Ohio.

[While the foregoing is true for new cylinders, it is quite usual to fit new rings to old cylinders by scraping. —Editor.]

A Lubrication Kink

The lubricator on a small exciter engine is mounted in a rather awkward position, about seven feet from the engine-room floor. The sketch shows a handy method used for refilling this lubricator.

The hand oil pump is mounted on the steam chest of the engine. A valve *A* is connected to the side



HAND PUMP FOR FILLING LUBRICATOR

outlet of the tee *B*, for pumping oil directly to the steam inlet of the engine. The drain cock *C* of the lubricator was changed from the bottom of the lubricator to the top of the oil gage glass. To refill, the lubricator is shut off in the usual manner; then the cock *C* and valve *D* and pet-cock *E* are opened and the lubricator is drained. Next the pet-cock *E* is closed and oil is pumped by the hand oil pump until the lubricator is filled, after which the valve *D* and the cock *C* are closed and the lubricator is again put in service.

Denver, Col. W. R. WEISS.

Loose Screw Caused Loss of Vacuum

A 1,000-kw. turbine geared to a 250-volt d.c. generator has been running for the last six years in one of our large plants, but one morning about three weeks ago the engineer could not get a vacuum. Another machine was started and a search was made for leaks, but none were found. Occasionally, the vacuum would come up to 28 in. only to drop back. After three weeks of investigation on the part of our engineers and experts from the manufacturer, the chief decided to remove the asbestos covering from around the main steam chest and examine the machine for possible defects in the casting.

He found three $\frac{1}{8}$-in. screw plugs where the casing had been tapped for shop tests, and one of these was so loose that it dropped out when the covering was removed. Another was loose but still in place. On tightening up these plugs, the machine was started and the vacuum immediately went to 28.8 in. and stayed there without any further trouble.

The screw plugs had worked loose for some unaccountable reason, and the vibration of the machine caused them to act like a check valve, sometimes sealing the tap hole and at other times allowing air to flow into the casing.

Washington, D. C. W. R. METZ.

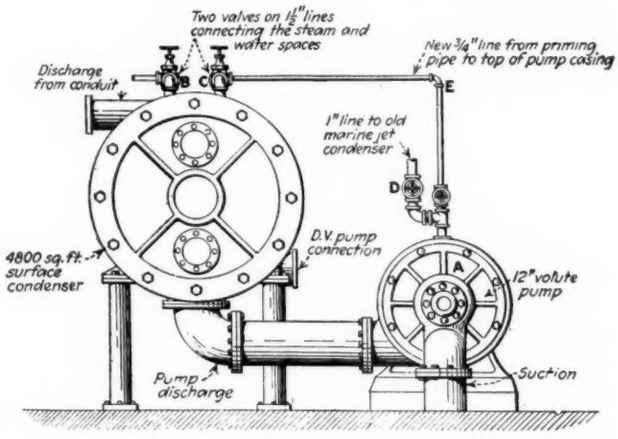
Condenser Trouble Solved

A condenser installation that has been in use since 1912 is shown in the illustration. The volute pump *A* is of the undershot type. The mean lift is approximately ten feet. The method used to pick up the condensing water was as follows: The hotwell and dry-vacuum pumps were started, with the circulating pump just turning over. Then the two $1\frac{1}{2}$-in. valves *B* and *C*, connecting the steam and water spaces, were opened. Water could always be lifted to these valves, but even then the circulating pump would not pick up the water with any degree of certainty. Frequently, it was hours before the water was picked up.

Near-by stood an old marine-type jet-condenser pump serving a 600-kw. engine. Someone conceived the idea of connecting this pump to the circulating pump to assist in picking up the condensing water. A 1-in. pipe *D* was connected as shown. With this arrangement water could be picked up in fifteen to twenty minutes.

This arrangement was satisfactory except when the old marine condenser pump had to be run during the day or when it was shut down for repairs. In such cases the circulating pump was run continuously. I might say that this main unit was run only during the peak load each evening, which means that the circulating pump would be running about eighteen hours, as a total loss. This practice was kept up for eight years, and it was believed that it was impossible for this condensing unit to lift its own water.

During the last annual overhaul it was proposed to connect the top casing of the pump to the steam space of the condenser in a similar way to that shown by the $\frac{3}{4}$-in. pipe *E*, from the pump to the priming pipe. After much opposition this was done, and the valve in this



CONNECTION BETWEEN PRIMING PIPE AND PUMP

line is opened when the two priming valves are opened. The pump casing is now filled with water long before any shows at the priming valves, and the whole operation takes from three to five minutes.

The reason the pump would not pick up water with any degree of certainty, as first connected, is that, it being an "undershot" pump, the air was not exhausted from the upper part of the casing, therefore the impeller was never submerged sufficiently for it to start the flow of water. The new connection simply exhausts the air from the pump casing to the condenser, thence to the air pump.

W. A. ANSON.

Baltimore, Md.

In the Light of History

The remarks in the editorial, in the Jan. 25 issue, "In the Light of History," are most happy, and it suggests a line of study of the past which many engineers, both technical and practically trained, might well take to heart and act upon.

Any trained engineer who has voted for three or four Presidents, well knows that hundreds of false ideas presented to them, often having cost their presenters much thought and money, would never have been given five minutes thought had they studied what had been done in the past in the same line. The trained engineer sometimes gets astray in his line of thought. I have seen this happen many times, and it was not so much the forgetting of thermodynamics and physics as it was the utter lack of knowledge of what had been done by others in the past that caused the waste of time.

We are now proposing to erect a monument to James Watt in recognition of what he did for the profession and the world, but to simply have his name on the monumental shaft would be regrettable. Here is the story that T. A. Weston told me as to Watt's early struggles in building his first commercial steam engine.

The most fortunate circumstance that ever happened for the engineering world was the meeting of Watt and that hard-headed, practical man, Boulton. Watt was a dreamer; Boulton was the opposite, practical in every fiber. Both men had determination of the highest order, or we should not have had the engine with a separate condenser, perhaps, for years.

These two men went to work to produce Watt's engine, and their troubles were great indeed. Their tools were inadequate and their money small in amount. It was some time after their first engine was built that Boulton wrote Watt in Paris, that he had bored a cylinder and fitted its piston so closely that "You could not get a shilling piece between the two at any point." What, then, must have been the condition of the cylinder and piston in the first engine?

The financial struggle was terrible for these grand men, but they never would have been able to succeed had it not been for an equally grand woman, Mrs. Boulton. She gave up everything so that the work could continue, and when at last the engine was almost finished she parted with a few silver spoons and trinkets given her when she was married.

This was just a little too much for her mind, and as the first commercial engine was successfully started, men drew her dead body from Soho Pool, where, after her last self-sacrifice, she had thrown herself.

Surely, every exhaust of the thousands and thousands of steam engines since built has been a requiem to her, and when a monument is erected to Watt it should not be a single figure but three—Watt and Boulton and above them the figure of a devoted wife and noble woman.

Such an example as this will spur us on to gain the victory over all obstacles and lead our thoughts to the fact that determination will at last succeed.

I have recently had a case where just a little knowledge of the work of early engineers would have saved a man much work and money. This man had reinvented Wolf's compound engine. I am constantly meeting men who are going over the work of some of the earliest inventors, simply because they have not taken the trouble to see what the past can show. I do not know of a single valve motion, save the Stephenson link, that has not been brought to me by friends or clients as their invention. These reinventions have by no means been presented by non-technical engineers only.

As for boilers it seems to me that reinventing is "a continuous performance" with designers—not just men who have used the shovel or have driven rivets, but men who have had every possible educational advantage.

Some years ago the Babcock & Wilcox Co. put out a book in which about every known design of boiler was illustrated. I owe that concern my very best thanks for the publication, as I would pull it down whenever a new boiler designer turned up, and I always found the identical idea therein set forth.

I have a copy of the book yet, and it is a most valuable work for any engineer to read. It was beautifully gotten up, and on its cover was a picture of Hero's æolipile revolving in a sea of vapor. With each style of boiler design were a few admirable words of explanation. Anyone interested in boiler design should get a copy of this book; it would save many thousands of dollars were it known and studied. Some old-time books, such as "Bourn on the Steam Engine" and "Bourn's Catechism of the Steam Engine," are well worthy of study today. I was told that the latter was written by Bourn, the secretary of a little club of engineering men, after he had gathered the information from its members who used to meet to talk over steam-engine problems and who hunted up information for their fellow-members to profit by. I have copies of these books, and in one is an illustration of the old Gouch steam-engine indicator; it is seldom found even in old publications.

I remember in a book by the same author published about 1862-63, just before the "Monitor" was launched, that he referred to it as a design that, "Like most odd naval productions, would turn out to be of little value and would probably never be tested out or brought into action."

I came across the Atlantic once with an engineer, a Dane, who was bringing to this country a perfect model of the Green cutoff and he would not believe that his idea had been anticipated.

To me the study of the past is alluring, not only as to its practical value, but to mark the bent of mind under conditions which at one time or another existed. From now on and, in fact, ever since the art of printing has been practiced, the records of what has been accomplished are fairly well distributed, and the great mass of valuable information to which workers in all lines of engineering have contributed makes it a matter of grave concern as to how this information can be tabulated so as to be quickly available. The technical journals are the very best means of keeping up with the times, but the times recede and the question is, how to know when and where what we have read can again be found. I have known of but one man who had a system which would enable him to attain this most desired end. He had a card-index system and he recorded, under proper headings, every article pertaining to his particular line of engineering appearing in the publications which he saw—and he saw a large number of them. I tested him out several times and found he could turn and give me the name of the publication in which the subject I wanted to know about could be found. Besides the articles of late date his index also showed the publication in book form almost in full, of all earlier works. The fund of information shown on his cards was of

the greatest value to him, and it was his idea to begin a consulting engineer's career when he was fifty years old and deal only in information that would guide his clients in their search for information, and I think that such an idea would have found favor in the sight of many.

I would suggest in conclusion, Follow the advice of the editorial and study the history of past engineering, index what seems of note to you and by all means read the publications of today and keep up with the times.

New Orleans, La. W. D. FORBES.

Data on Motor Operation

In the Jan. 18 issue of *Power* Mr. King inquires about maintenance costs on small induction motors and mentions a rather large difference in winding costs. These differences in operating costs are sometimes rather difficult to explain. I have in mind two large installations that have approximately similar conditions of operation. The motors are about the same age, were made by the same manufacturer under the same specifications and have about the same speed and horsepower range. There does not appear to be any radical difference in the methods of handling so far as electrical upkeep is concerned. Both plants have between 300 and 400 motors from 1-hp. to 400-hp. capacity. Apparently, these plants should show very similar costs. In the one case one motor has been rewound in a year and a half and in the other the rewound motors form a considerable percentage of the total each year. The difference in this case comes in the way the motors are handled by the operating crews. The damage can largely be traced to elements not under the control of the electrical department, such as flooding with water from the process, extra loads from misalignment of driven machinery, and metallic deposits on the coils derived from the process. Under these conditions it becomes a matter of plant-operating policy and comparative figures are deceptive.

Regarding the other points in question, operating conditions vary so much that little of a definite nature can be said. It is my practice to inspect motors with a feeler gage in the air gap at regular intervals. These intervals will vary with the severity of the operating conditions. In ordinary service the inspections should be made once a week or at least once a month. For the majority of small motors a clearance of 0.015 in. to 0.010 in. may be considered as minimum and the bearing should be changed when the gap is reduced to that size on the pull side.

The life of a ring-oiled bearing will depend on its service and the material of which it is composed. Under good conditions it should last from four to five years on the average. I have found that most any high-grade engine oils are satisfactory for almost all motor bearings up to a speed of 1,700 r.p.m., and have discarded the so-called special dynamo oils as unnecessary with proper attention. Where dust or lint is present, the oil will be gradually siphoned out of the bearings and it may be necessary to inspect the oil every day. Under favorable conditions a motor should run two or three months with no attention to the oil in the bearings. Under very dirty conditions, with bearings not dustproofed, it may be necessary to wash out the oil well once in two weeks. This period will vary, but it appears advisable to wash out the wells at least yearly and always after a bearing has shown signs of heating.

Where a motor is protected by double inverse-time element overload relays, it would appear logical to set them at 100 per cent full-load current unless operating conditions require a higher setting. It is usually inadvisable to set relays of these characteristics much above 125 per cent. In case of 50-deg. motors they should not be set above 100 per cent. In general the relays should be set as low as the loads on the motors will permit without interfering with their regular operations.

With the majority of remote-control apparatus all phase contacts are thrown by the same operating mechanism and single-phase operation can occur only through defective contacts. Apparatus of this character should be inspected frequently and should be free of this defect if properly maintained.

It would appear that these points must be determined for each plant, and comparisons can be used only as a guide and not an absolute rule to follow without proper analysis. T. H. ARNOLD.

El Paso, Tex.

Are Small Boiler Tubes Desirable?

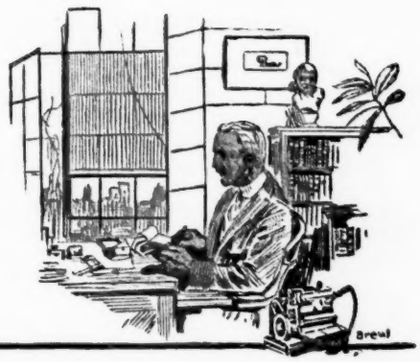
I have just noted Mr. Riggin's inquiry relative to the advisability of using a large number of small tubes (I suppose he means 3-in. tubes), instead of the usual number of 4-in. tubes, and I am constrained to offer a suggestion or two that may be of interest, for I have no doubt that in New York City and other Eastern places, this is a much-debated question, but with us engineers of the West the smaller tubes were shunned ages ago, for they caused us untold trouble.

If the top row of tubes is placed too high, the steam space will be reduced to a point where foaming and priming will become a common nuisance. If the tubes are crowded too close to the sides of the shell, the circulation of the water will be decidedly retarded, and especially is this the case when the tubes have taken on a coating of scale and thus increased their outside diameter very materially. Tubes placed in the extreme lower part of a boiler are not very effective generally. As to the fuel to be burned, I am convinced that this is a much debated question, for the future supply from one source is not likely to be possible unless anthracite is being burned, and of course all of that comes from practically the same location. In the East there are found the Dominion coals from Sydney, and Pennsylvania, Virginia and Maryland coals, most of which are bituminous and can and do make smoke, and smoke means soot, and that means inefficient heating surface in the tubes. Some of these coals have more ash than others, and under certain draft conditions this ash is carried into the tubes and lodges there until it is removed. This deposit of ash and soot not only makes the tubes heat-retarding, but also reduces the capacity for carrying their proper volume of gas from the combustion chamber, thus making that tube very non-effective as a heat absorber.

Out West, where we have the Illinois, Iowa, Missouri and Kansas coal and the lignitic coals from Wyoming, Montana and the Dakotas, we have learned to have nothing less than 4-in. tubes, and then to keep them clean inside and outside. Possibly in the burning of coke and the very high grades of bituminous coals, a boiler with 3½-in. tubes under certain operating conditions peculiar to Eastern requirements would prove economical and efficient. ROYAL H. HOLBROOK.

Cedar Rapids, Iowa.

INQUIRIES OF GENERAL INTEREST



Lubricating Oil for Diesel Engines—Is it good practice to use the same lubricating oil for the piston and the main bearings in a semi-Diesel engine? H. C.

Most manufacturers provide a single mechanical lubricator for supplying the same lubricant to all parts of the engine. In choosing an oil for such general use, it must not be too heavy for the bearings or too light for the piston. Undoubtedly, a separate oil for each duty would be better.

Heat of Combustion to CO or to CO_2—What is the relative heat obtained from combustion of the carbon of a fuel to CO as compared with combustion to CO_2? R. W. G.

When carbon is burned completely to CO_2, there will be approximately 14,500 B.t.u. given off for every pound of carbon burned. This quantity is called the heat of complete combustion of carbon. If there is not a sufficient supply of oxygen present and the product is CO, then there are only about 4,400 B.t.u. given off for each pound of carbon so burned. Hence, for every pound of carbon burned to CO in place of CO_2 there is a loss of about 14,500 — 4,400 = 10,100 B.t.u.

Operation of Lapless Corliss Valves—With a single-eccentric Corliss engine having all valves set without lap when the center of travel of the wristplate is in the central position, what would be the effect of advancing the eccentric? W. N.

Advancing the eccentric makes all the valve events earlier. There would be earlier release and earlier closure of the exhaust, but with lapless valves all would reach their port edges at the same time and each steam valve would begin to open at the instant the exhaust valve of the same end became closed; hence in place of compression there would be excessive lead. To prevent this it is necessary to add lap to the steam valve so it will remain closed during the period of compression.

Cleaning Fire of Hand-fired Boiler—What is a good method of cleaning the fire of a hand-fired horizontal return-tubular boiler using soft coal with stationary grates? B. N. Y.

The method should be one that can be employed for cleaning and restarting the fire as quickly as possible. A good method is to clean the sides of the fire alternately. Build up a good fire on one side of the grates and burn down the side to be cleaned. Then draw the ashes and wing the burning fire over the clean grates and spread with a sprinkling of fresh coal. By this method the rear end of the fire can be thoroughly cleaned and there is no need of leaving a large quantity of ash and clinkers next to the bridge wall to cause considerable loss of effective grate area.

Crushing Strength in Front of Rivet—In considering the strength of a riveted joint, what is meant by crushing strength of a rivet and crushing strength of plate in front of the rivet? W. H.

The force tending to shear the rivet is the same as the bearing pressure exerted by the edge of the plate in front of the rivet against the shank of the rivet. The bearing pressure is calculated per unit of projected area taken as the product of thickness of the plate multiplied by the diameter of the rivet. This area multiplied by the mutual crushing strength of the rivet and plate material, usually assumed as 95,000 lb. per sq.in. for mild steel, gives the resistance to crushing, and failure from that cause may be regarded as occurring from insufficient crushing strength of the rivet or of the plate in front of the rivet.

Flywheel Unnecessary for Direct Steam Pump—Why can a boiler-feed pump be run without a flywheel? F. N. C.

In direct steam pumps used for boiler feeding, a flywheel is unnecessary because the resistance is nearly constant with steam following the piston the full length of the stroke, and there is provision for proper admission of steam for reversal of the pump when the piston has reached the end of a stroke. In single direct steam pumps admission of steam to the cylinder for obtaining reversal is effected by a steam-thrown main valve whose position is controlled by an auxiliary valve which admits steam for giving proper position to the main valve when the pump is at or near the end of a stroke; and in a duplex steam pump each side, before reaching the end of its stroke, reverses the valve of the other side.

Long and Short Shunts for Compound Direct-Current Machinery—What are the advantages and disadvantages of the long and short shunt-field connections for compound-wound direct-current machinery? F. W.

There is practically no difference between the two connections so far as normal operating characteristics are concerned. However, the long shunt is preferable for compound generators, for at times of heavy overloads or short-circuits the large drop in the series field decreases the voltage impressed on the shunt windings and so tends to relieve the load on the machine. In case of compound motors equipped with special control devices, such as dynamic breaking or short-circuiting of the series field after the motor has reached a certain speed, the long shunt is also preferable to the short shunt. Otherwise the two connections may be used indifferently on motors.

Power Output of Induction Motor—What is the horsepower output of a 50-hp. three-phase 60-cycle induction motor when it takes 80 amperes per phase at 580 volts from the line? N. H. H.

It is not possible to obtain exactly the horsepower output of an induction motor from the voltage and the current alone. The power factor must be known, or the power input in kilowatts, and the efficiency at different loads. It may be obtained approximately, however, for small motors, by assuming one kilovolt-ampere input to produce one horsepower output. In the case in question,

$$\text{Input} = \frac{80 \text{ amp.} \times 580 \text{ volts} \times 1.732}{1{,}000} = 80 \text{ kva.},$$

which on the foregoing assumption corresponds to an output of 80 hp. The motor is therefore operating under approximately 60 per cent overload.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Superpower Idea Gaining Ground in England

A plan that is very similar to the superpower project contemplated in this country has recently been approved by a conference of local authorities owning central stations in Greater London, England. It is proposed to shut down progressively thirty-four stations and by means of interconnections supply them with power from the remaining plants. Meanwhile power stations will be built, and as they are put into operation, twenty-six of the remaining generating stations would be progressively shut down. Of the remaining seventeen plants in the area, two would be reconstructed and considerably enlarged to act as superpower stations, while seven would be permanently kept as auxiliary plants in conjunction with the superpower plants. The other eight stations near the outskirts of the area would have to be kept at work for a considerable period to serve the local demands until it should become possible to extend the transmission lines to their neighborhood.

The capacity of the new superpower plants will vary between 70,000 and 200,000 kw., mostly in units of 25,000 kw. Some of the locations selected will permit of much larger stations if they are required.

It is proposed to allow existing generating stations used solely for street railways and railroads to supply energy as at present to their respective systems, while any railroad not already electrified may obtain energy from the superpower system. All these plants are steam stations; there are no water-power resources in the area.

Power and Fuels To Be Discussed at A. S. M. E. Spring Meeting

The program for the Spring meeting of the American Society of Mechanical Engineers at Chicago, May 23-26, is now almost complete, and it contains a number of items that should be of considerable interest in the power-plant field.

On the morning of the first day of the meeting, Monday, May 23, the council will meet, and in the afternoon there will be a business meeting at which Morris L. Cooke will read a paper on the "Organization of an Engineering Society." The discussion of this paper will be carried over into the management session on Tuesday morning. In the evening (Monday) there will be a reception and dance at the Congress Hotel.

On Tuesday morning, May 24, at 10 o'clock, there will be four simultaneous sessions—the fuel, the machine shop, the management and the general session.

In the fuel session the burning of mid-Western fuels will be the general subject and the following papers will be given: "Recording Ash-Pit Loss from Chain-Grate Stokers," by E. G. Bailey; "Boiler Tests with Pulverized Fuel," by Henry Kreisinger and John Blizard; "Limitations of Mechanical Stokers Utilizing Mid-West Coals," by E. H. Tenney; "Capacity and Efficiency Limitations of Stokers Using Mid-West Coals," by John E. Wilson; "Discussion of Smoke Production with Reference to the Health of the Community," by Dr. John D. Robertson; "Latest Requirements of the City of Chicago in Furnace Design with Special Reference to Hand-Fired Boilers and Limits of Each Design," by Frank Chambers.

In the general session papers will be presented by S. B. Redfield on "Capacity Tests of Dry Vacuum Pumps" and by H. B. Reynolds on "Results of Turbine Tests on Three 30,000-kw. G. E. Turbines."

Tuesday afternoon has been set aside for excursions. In the evening there will be a session on "Training in Industry."

Wednesday morning, May 25, will be devoted to a local session on "Problems of Chicago as a Rail-Water Gateway," to a public hearing on the power test code, and to a general session at which three papers will be presented. They are: "Investigation of Oxyacetylene and Cutting Blowpipes," by R. S. Johnston; "Interpretation of Boiler Water Analyses," by J. R. McDermet; "The Development of the Hydraucone Regainer," by W. M. White.

In the afternoon more excursions will be made and in the evening another dance will be held.

Thursday morning, May 26, there is to be a railroad session, a materials handling session, a forest products session and a power session. No papers for the power session have as yet been announced, though it is understood that two papers will be presented on the general subject of "Power Resources of the Middle West." In arranging for this session the power division is co-operating with the Chicago section of the American Institute of Electrical Engineers; the mechanical and electrical sections of the Western Society of Engineers is to furnish the program.

Thursday afternoon there will be more excursions and some moving pictures.

Before the main meeting commences there is to be an excursion to the McCook Aviation Field at Dayton, Ohio. The visit is being arranged by the aëronautic division jointly with the Society of Automotive Engineers, but the entire membership of the society is invited to stop off at Dayton on the day of the trip, which will be Saturday, May 21.

Another excursion will be made, after the main meeting, to the Rock Island Arsenal, where the ordnance division will give a program. This trip will be made on Friday and Saturday, May 27 and 28; Friday will be spent in inspection trips and in the ordnance session, and on Saturday there will be a golf tournament on the Rock Island Links.

The headquarters of the meeting will be at the Congress Hotel, Chicago. The national headquarters of the society are at 29 West 39th Street, New York City, and the secretary is Calvin W. Rice.

Another convention will follow the A. S. M. E. meeting in a few days; the National Electric Light Association is to hold its annual convention at Chicago, May 31 to June 3. The program of the latter meeting will appear in an early issue of *Power*.

How Coal Prices Have Changed

A table appearing in *Commerce Monthly* for April shows very clearly the fluctuations that took place in the prices of anthracite and bituminous coal at the mine during 1913, 1914, 1915, 1916, 1919, 1920 and 1921. These figures will bear repeating here for their interest to users of coal. The war period, covering 1917 and 1918, is omitted as abnormal. In the table, A-buck is anthracite, No. 1 buckwheat, f.o.b. lower ports, N. Y.; A-stove is anthracite, stove, f.o.b. mine; B-Fair. is bituminous, run of mine, f.o.b. mine, Fairmont, W. Va.; and B-Pitts. is the same, Pittsburgh District. The figures for the latter part of 1920 are especially interesting.

WHOLESALE COAL PRICES

The figures given are per gross ton, except those for the Pittsburgh District, which are per net ton.

1913	A-Buck.	A-Stove	B-Fair.	B-Pitts.
January	$2.40	$4.00	$1.35	$1.30
April	2.40	3.50	.85	1.30
July	2.25	3.80	.90	1.35
October	2.35	4.00	1.05	1.40
1914				
January	2.25	4.00	.85	1.30
April	2.40	3.50	.80	1.30
July	2.15	3.80	.80	1.30
October	2.35	4.00	.75	1.30
1915				
January	2.45	4.00	.75	1.15
April	2.45	3.50	.75	1.05
July	2.15	3.80	.80	1.00
October	2.40	4.00	.80	1.05
1916				
January	2.75	4.10	1.85	1.25
April	2.00	3.60	1.00	1.05
July	2.40	4.20	1.20	1.30
October	2.80	4.40	2.75	3.25
1919				
January	4.45	6.10	2.50	2.35
April	4.75	6.10	2.50	2.25
July	4.75	6.40	2.40	2.25
October	4.75	6.60	2.80	2.35
1920				
January	5.25	6.60	2.80	2.35
April	5.75	6.60	4.25	4.25
July	6.50	7.65	12.00	10.00
October	8.00	8.00	10.75	9.00
1921				
January	6.75	8.00	2.75	2.75
February	5.75	8.00	2.50	2.50
March	5.25*	7.40†	2.00	2.25

*Range, $5 to $6. †Range, $7.40 to $8.05.

A Survey of Canadian Electric Stations

A comprehensive report on central electric stations in Canada for 1918 has recently become available. It is somewhat late, as is so often the case with government publications, but it contains a large amount of valuable data, the most important of which has been summarized here as briefly as possible.

In considering this material, the reader should carefully bear in mind that it applies only to Canadian central electric stations, which are defined in the report as those that sell or distribute electrical energy for lighting, heating or general power purposes.

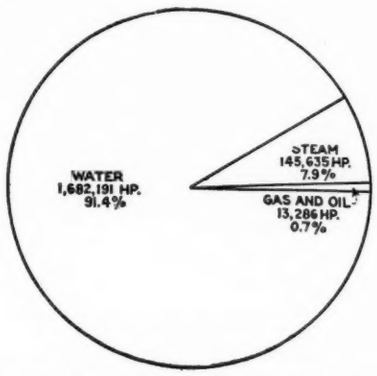


FIG. 1. THE SOURCES OF CANADA'S POWER
The total is 1,841,112 hp.

A notable feature of the report is the large amount of water power developed in comparison with other kinds of power (See Fig. 1). In addition to the 1,841,112 primary horsepower there was 117,528 hp. installed in stand-by and auxiliary plants. It is interesting to consider the fields of the different sizes of units, as shown in Fig. 2. The reciprocating engine was widely used in sizes up to 2,000 hp., but above that class it was entirely displaced by the steam turbine. Water turbines are far ahead in all classes, especially in the very large sizes.

The distribution of power production in the different provinces was as follows: Alberta, 75,915; British Columbia, 217,184; Manitoba, 75,142; New Brunswick, 18,563; Nova Scotia, 19,565; Ontario, 780,211; Prince Edward Island, 1,353; Quebec, 611,744; Saskatchewan, 31,215; Yukon, 10,220. These figures do not include the 117,528 hp. installed in auxiliary and stand-by plants.

The capital invested per horsepower installed is given as $218. This ratio ranged in the separate provinces from $168 in Alberta to $343 in Yukon. The total operating expenses amounted to $16.44 per installed horsepower. There were 5.2 employees per 1,000 installed horsepower.

Table I shows the quantities of different kinds of fuel used and the amounts that were imported and supplied by Canada itself.

In Table II are given figures for different types of stations, showing the number, the primary horsepower installed and the capital invested. The stations are classified in three ways—according to whether they have generating apparatus or simply buy power and redistribute it; according to whether they are privately or municipally operated, and according to whether they are operated entirely by water power, steam power or gas or oil power. There were six stations that had combinations of two or more kinds of apparatus, as, for instance, water power and steam.

TABLE I. THE DIFFERENT KINDS OF IMPORTED AND DOMESTIC FUELS CONSUMED

Kind of Fuel	Canadian	Foreign
Bituminous coal, slack, tons	111,463	61,050
Bituminous coal, lump, tons	29,888	9,792
Bituminous coal, run-of-mine, tons	62,272	28,775
Anthracite coal, tons	910	12,386
Lignite coal, tons	176,707	.....
Coke, tons	101	.....
Total, coal and coke, tons	381,341	112,003
Gasoline, gal	16,519	810
Oil fuel, gal	385,768	153,314
Wood, cords	11,000	.....
Gas, 1,000 cu.ft	6,771,837	.....

TABLE II. A COMPARISON BETWEEN VARIOUS TYPES OF STATIONS

Type of Station	Number of Stations	Primary Hp. Installed	Capital Invested
Totals	795	1,841,112	$401,942,402
Generating	515	1,841,112	364,653,246
Distributing only	280	.....	37,289,156
Commercial	377	1,434,194	288,151,605
Municipal	418	406,918	113,790,797
Hydraulic	280	1,682,191	326,678,516
Steam	141	145,635	37,974,730
Gas and oil	88	13,286	

An article that appeared in *Power* for Dec. 14, 1920, on page 956, entitled "Canada's Use of White Coal," might be interesting to look up in connection with the matter presented here. The figures given in the previous article do not correspond exactly with those given here, because they were prepared by another organization at a somewhat later date. The discrepancies are, however, no greater than would naturally be expected. Those who want more complete statistics on this subject may obtain the original pamphlets from which these figures were taken by writing to the Dominion Bureau of Statistics, Ottawa, Canada. The booklet is Sessional Paper No. 17b, a Report on Central Electric Stations in Canada from the 1918 Census of Industry.

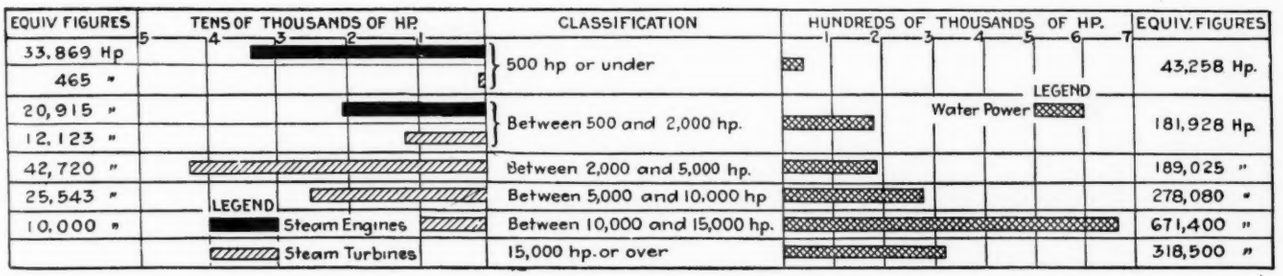


FIG. 2. THE AMOUNT OF POWER PRODUCED BY DIFFERENT SIZES OF UNITS
Note that the water-power and steam-power charts are not visually comparable as they are necessarily drawn to different scales.

A maker of Diesel engines once declared that the best records were made with engines shipped to the Far East and put in charge of native mechanics, who might be trusted to follow directions implicitly without attempting on their own initiative to vary the adjustments. This restraint appears impossible to the British mechanic, and we would not say that it constitutes anything to his discredit. The very self-confidence which occasionally leads him to make unneeded and possibly injudicious adjustments or alterations when things are normal, constitutes a priceless asset in times of crisis. Still, those who install internal-combustion marine engines must accept certain risks in this regard, though these will naturally decrease as time goes on and engineers with experience in the operation of this class of machinery become more numerous.—*Engineering.*

New Publications

KONSTRUKTION UND MATERIAL Im Bau von Dampfturbinen und Turbodynamos (Design and Materials for Steam Turbines and Turbo-Generators.) By Dr. O. Lasche, Direktor der Allgemeinen Elektrizitats Gesellschaft. Published by Julius Springer, Berlin; Octavo; 178 pages.

The book calls attention to the rapid development of the steam turbine in competition with other large power units, showing how the capacity of the individual steam-turbine unit has increased in the last twenty years more than tenfold. Inasmuch as a limiting feature in steam-turbine construction is the strength and endurance of the materials available, the book goes quite exhaustively into the use made of present-day materials, explaining their limitations for design purposes and the troubles experienced with them in practical operation.

The first chapters treat of the determination of the physical properties of materials, describing the usual methods of the laboratory in determining from test pieces the elastic limit, ultimate strength and elongation of materials and also describing a method of impact testing of specimens. Results are given of the laboratory investigation of subjecting specimens to alternations of stresses, both at ordinary temperatures and at the higher temperatures encountered in steam-turbine work, for the determination of the number of alternations required for failure

Turbine buckets erode and corrode, due to a great many causes, and the book goes into a detailed discussion of these causes, such as rusting, cutting by moisture in the steam, chemical action, abrasion due to boiler compounds carried through with the steam, and electrolysis. Failure of the buckets caused by excessive handling or vibration is also discussed. Photographs are shown of buckets that have been badly eroded and corroded. The author does not, however, give any very definite cures for all these troubles.

A chapter is devoted to the generator end of the unit, and the usual Allgemeinen Elektrizitats Gesellschaft construction of rotor is described. Tests made on the strength of the punchings used, the method of forging the generator shaft, and the securing of test pieces are all described. All these, however, are ordinary processes and are well known. Both the turbine and generator shaft are heated to the highest temperatures to which the shaft would be subjected and carefully indicated in a lathe to be sure the shaft will run true under heated conditions.

A chapter is devoted to the troubles experienced with the erosion or eating away of condenser tubes, due either to chemical reactions, electrolysis or the deposit of foreign material on the tubes. Excellent micro-photographs are shown of various brasses used in condenser-tube manufacture and their appearance after being subjected to electrolytic disturbances either generally or locally. The installing of iron and zinc plates in a condenser for preventing chemical attacks and electrolysis on the condenser tubes is shown; the method described is used in this country.

Various designs of turbine bearings are shown. Experimental results are given of the investigation of the distribution of bearing pressures throughout turbine lining, and the latest designs of turbine bearings and thrust bearings are shown. These experimental results and the determination of the coefficient of friction agree with data that have been published in the technical press in this country and are, therefore, not new.

Speaking generally, the book contains very little experimental data or information as to turbine design or the materials used in turbine design which has not hitherto been published or known. It gives, however, to those interested in the future of the turbine industry, a very good insight into the present limitations both from a designer's point of view and from a practical or operating point of view. The designer, if he could secure reliably producible steel having better physical properties, could easily go to larger outputs per unit than at the present time. A great deal of experimental work is still necessary in securing materials for turbine-bucket manufacture that will meet the newer requirements of higher temperatures of steam and that will not easily erode or corrode. The proper building of condensers and installing of them so as to prevent both chemical and electrolytic destruction of condenser tubes needs very careful research work. The limitations of pressures that can be carried on bearings, and means of not only lubricating them but also dissipating the heat of friction require skillful attention. All these things are well known to the turbine designer, and much progress has been made in this country and no doubt also in Europe in recent years, along these lines. Special attention has been given in the book to the illustrations and to the reproduction of micro-photographs of the structure of steel under various heat treatments. L. C. LOEWENSTEIN.

Obituary

George O. Hodgson, chief engineer of the Tide Water Oil Co.'s plant at Bayonne, N. J., died suddenly from heart failure on March 29 at Atlantic City. He was a member of the Masonic Order and of the Junior Order of American Mechanics. He was with the Tide Water Oil Co. for 40 years and leaves a son, Lester O. Hodgson, who is the engineer in charge of the company's new plant at Greenville, N. J.

Personals

Edward F. Miller, professor of steam engineering at the Massachusetts Institute of Technology, has been elected chairman of the faculty.

John M. Hartman has resigned his position with the Aluminum Company of America to take up work [illegible] the engineering department of the Kewanee Boiler Company, Kewanee, Ill.

Joseph P. Towson, formerly with the Bethlehem Shipbuilding Corporation at Sparrows Point, Md., is now in the engineering department of The Bartlett-Hayward Company, Baltimore, Md.

Robert McF. Doble has been appointed on the staff of the Metals Exploration Co., New York City, as consulting engineer with respect to electric and hydro-electric power installations and operations, with headquarters at 201 Fourteenth Street, Denver, Colorado.

Society Affairs

Buffalo Section, A. S. M. E., will meet April 26 to hear "Steam Flow" discussed by E. G. Bailey.

Philadelphia Section, A. S. M. E., will meet April 26 to hear an address by Edward G. Budd on "The Spirit of Management—an Attitude of Mind."

The Providence Engineering Society will meet April 19 to hear a speech on "The St. Lawrence Development and its Meaning to New England," by Henry I. Harriman.

St. Louis Section, A. S. M. E., will hold a meeting April 29 at the American Hotel. H. I. Gentine, of the American Atomized Fuel Co., will speak on "Powdered Fuel."

Akron Section, A. S. M. E., will hold a joint meeting with the Engineering Society of Akron on April 27. The speaker will be Dr. D. S. Jacobus, of the Babcock & Wilcox Co.

The American Society of Safety Engineers will meet April 22 at the Engineering Societies Building, New York City, to discuss "The Service to Safety Engineering Rendered by The Underwriters' Laboratories."

The American Society of Heating and Ventilating Engineers has extended the closing date of its semi-annual meeting by one day. The meeting, it is announced, is to be held June 14-17 at the Hotel Winton, Cleveland.

The American Welding Society will hold its annual meeting April 27-30 at the Engineering Societies Bldg., New York City. A technical session will be held on the 28th, at which automatic welding machines, production gas welding and thermit welding will be discussed.

Washington State Section, A. S. M. E., will hold a meeting on April 27 at the Engineers' Club of Seattle, at which Richard F. Daniels will give an illustrated lecture on "Personal Experiences in the Oil Fields of Oklahoma."

Illinois State Association, N. A. S. E., will hold its annual convention at Chicago June 8-10. In conjunction with the meeting the Central States Exhibitors' Association will hold a large exhibit of power-plant quipment and supplies at the Municipal Pier, Chicago.

Miscellaneous News

The Mechanical Engineering Society of the Massachusetts Institute of Technology, affiliated with the A. S. M. E., held its first annual banquet at Walker Memorial on Wednesday evening April 13. Prof. E. F. Miller, Jack Armour and F. R. Low, editor of *Power*, were the speakers.

The Gas Power Division of the A. S. M. E., which was authorized Dec. 10, 1920, has been organized and has now elected the following officers: Executive committee, Van H. Manning (chairman); Finley R. Porter Lawrence B. Jackson, B P. Flint and R. H. Burdick; secretary, William D. Ennis, 132 Nassau St., New York City.

The Appointment of an Engineer to one of the three vacancies on the Interstate Commerce Commission is being urged upon President Harding by American Engineering Council. A list of six engineers qualified for the appointment has been given the President, and representatives of the Council have been advised that Mr. Harding is considering their recommendation. In taking this action the Council is representing not only the member societies of the Federation, of which it is the governing board, but is also representing the American Society of Civil Engineers, the American Association of Engineers and the American Institute of Consulting Engineers, which have not yet joined.

Business Items

The Brown Hoisting Machinery Co., of Cleveland, Ohio, has announced the opening of a Southern office at 530 Whitney-Central Bldg., New Orleans. The States of Texas, Louisiana, Mississippi, Alabama, Georgia and Florida will be covered from this office, which will be in charge of Charles H. White.

The Engineering Business Exchange has opened a Southeastern branch in the McLachlen Bldg., Washington, D. C., with Marshall O. Leighton as director. Mr. Leighton is a Washington consulting engineer and was with the United States Geological Survey for twelve years. He will have as his assistant A. C. Oliphant.

Trade Catalogs

The Files Engineering Co., Inc., Providence, R. I., has gotten up a new 7 x 10-in. catalog of the Files hand-operated stoker.

The Underfeed Stoker Co. of America Detroit, Mich., is distributing a new 6 x 9-in. booklet entitled "Ten Points of Jones Superiority."

The Chicago Pneumatic Tool Co. is distributing a new 6 x 9-in., 8-page bulletin, No. 639, describing the B Q-46 hammer drill, which is designed primarily for demolition work.

The Taber Pump Co., Buffalo, N. Y., has issued a new 9 x 6-in., 20-page bulletin, No. SV-30, consisting principally in a large number of good photographs of volute centrifugal pumps.

The National Tube Co., Pittsburgh, Pa., is distributing a new 8½ x 11-in. 86-page book that is worthy of especial attention. It is beautifully gotten up and contains a good deal of interesting matter on the history of pipe and its manufacture. It describes numerous processes used in the making of "National" pipe, illustrating them with excellent photographs. It can scarcely be called a catalog; it is rather a most interesting book that tells the story of the making of "National" pipe.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	April 5 1921	April 12 1921
Pocahontas,	Columbus	$3.50	$3.35
Clearfield,	Boston	2.45	2.00@2.75
Somerset,	Boston	3.05	2.35@3.75
Pittsburgh,	Pittsburgh	2.25	2.00@2.50
Kanawha,	Columbus	2.35	2.25
Hocking,	Columbus	2.25	2.25
Pittsburgh No. 8	Cleveland	2.25	2.00@2.50
Franklin, Ill.,	Chicago	3.40	3.25@3.50
Central, Ill.,	Chicago	2.25	2.00@2.50
Ind. 4th vein,	Chicago	2.65	2.25@3.00
Standard,	St. Louis	1.95	1.85@2.00
West Ky.,	Louisville	2.40	2.00@2.75
Big Seam,	Birmingham	2.85	2.90@3.25
S. E. Ky.,	Louisville	2.70	2.50@2.75

DIESEL FUEL OIL

New York — On April 14, Port Arthur light oil, 23@25 deg. Baumé, 5⅜c. per gal. 30@35 deg., 6¼c. per gal. f.o.b. Bayonne, N. J.

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3¾@4¼c. per gal.

Cincinnati—In 8,000-gal. tank cars: 26@28 deg., 7c. per gal.

St. Louis — April 9 prices f.o.b. cars, tank lots: 24@26 deg. Baumé, 75c. per bbl.; 26@28 deg., 80c.; 28@30 deg., 85c.; 32@34 deg., 2¾c. per gal.

Baltimore—On April 12, f.o.b. Baltimore in tank-car lots: 24+ deg. Baumé, 6¼c.; 26@28 deg., 6¾c.; 30@34 deg., 7¾c.; 14+ deg., $1.95 per bbl., 16@20 deg., $1.85 per bbl.

Pittsburgh — On April 12, f.o.b. refinery; Pennsylvania, 36@40 deg., 5c. per gal.; Oklahoma, 22@24 deg., 60@70c per bbl., 24-26 deg., 75c. 26@30 deg., 80@90c.; gas oil, 32@34 deg., 2¼c per gal., 36@38 deg., 3¼c., 38@40 deg., 4c.

Philadelphia—On April 12; 26@28 deg. Baumé, Oklahoma, 85c. per bbl.; 30@34 deg., Oklahoma (group 3) 3c. per gal.; 16@20 deg., Seaboard, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Springfield—W. Lay, 340 Bridge St., plans to build a theater on Vernon St. About $600,000.

Mass., Winchester — Beggs & Cobb are having plans prepared for a boiler plant in connection with their leather factory, here. Six 200 hp. boilers and mechanical stokers will be installed in same. H. M. Haven and W. W. Crosby, 40 Court St., Boston, Engrs.

R. I., Providence—The Lederer Realty Corp., 100 Stewart St., will soon award the contract for the construction of a 4 story, 75 x 225 ft. business building on Washington and Clemence Sts., to cost about $600,000 and a 2 story showroom addition to present building on Weybosset and Broad Sts., to cost $75,000. W. R. Walker & Son, 17 Custom House St., Archt.

Conn., New Haven—A. H. Powell, 177 Church St., is having revised plans prepared for a 12 story, 64 x 90 ft. business building including a steam heating system on Church and Court Sts. About $1,000,000. R. W. Foote, 185 Church St., Archt.

Conn., Southington—Peck, Stow & Wilcox Co., Railroad Sq., plans to build additions to its hardware plant including a 1 story, 70 x 180 ft. hardening building, 2 story, 56 x 156 ft. grinding building and a 1 story, 60 x 100 ft. forge shop. About $300,000.

N. Y., Buffalo—Barnett Haynes & Barnett, Archts., Century Bldg., St. Louis, Mo., will receive bids about May 15 for a 10 story, 116 x 120 ft. apartment house including a steam heating system on Elmwood and Ferry Sts., here, for the Lincoln Real Estate Co., 15 West Eagle St. About $450,000.

N. Y., Buffalo—The Great Lakes Hotel Corp., Main and Goodell Sts., is having plans prepared for a 17 story, 110 x 200 ft. hotel on Main St. Gustave W. Drach, Union Trust Bldg., Cincinnati, O., Archt.

N. Y., Buffalo — Spencer Kellog & Sons Inc., Niagara Sq., are in the market for 1 steam pump, etc.

N. Y., New York (Borough of Brooklyn) —The Brooklyn Retail Butchers Corp., 3285 Fulton St., is having plans prepared for a 3 story, 130 x 135 ft. refrigeration plant on Atlantic Ave. and Ft. Greene Pl. About $250,000. Jallade, Lindsay & Warren, 129 Lexington Ave., New York City, Archts. and Engrs.

N. Y., New York (Borough of Brooklyn) —The Transit Constr. Comn. received bids for the installation of a drainage pump in the Subway at North 7th and Havemeyer Sts., from V. S. Rittenhouse, 243 East 57th St., New York City, $750. Wagner Elevator Co., 435 Pearl St., $835; Lewis A. Woods, $843.

N. Y., New York (Borough of Manhattan)—E. Carroll, 212 West 42nd St., is having plans prepared for a 4 story, 100 x 140 ft. theatre and office building including a steam heating system on 7th Ave. and 50th St. About $300,000. G. Keister, 56 West 45th St., Archt. and Engr.

N. Y., New York (Borough of Manhattan)—The Joint Ownership Corp., 7 East 42nd St., is having plans prepared for an apartment house including a steam heating system on 67th St. between Lexington and 3rd Aves. About $500,000. Walker & Gilette, 128 East 37th St., Archts. and Engrs.

N. Y., New York (Borough of Manhattan) — The Reconstruction Hospital, 395 Central Park West, plans to build a hospital building including a steam heating system on 100th St. and Central Park West. About $1,000,000. York & Sawyer, 50 East 41st St., Archts and Engrs.

N. Y., Niagara Falls—The Niagara Lockport & Ontario Power Co., Marine Bank Bldg., Buffalo, is having preliminary plans prepared for a hydro-electric power plant, here.

N. Y., Rockaway, L. I.—The Bd. Educ., 500 Park Ave., New York City, will receive bids until April 22 for a 1 story addition to school No. 44, including a steam heating system. About $250,000. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Rossie — The Rossie Electric & Mfg. Co. plans to make repairs and build additions to the power house, dam and flume. Estimated cost, between $30,000 and $35,000. The company plans to install a new 400 hp. generator and water wheel also. Address George N. Wilson.

N. Y., Watertown—The City Council has had pans prepared by W. H. Cushman, Consult. Hydraulic Engr., for the development of the water power on the Black River at Delanos Island. The city plans an election to vote an appropriation of $500,000 for the project.

N. Y., White Plains—The Joint Ownership Corp., 7 East 42nd St., New York City, is having plans prepared for an apartment house including a steam heating system. About $300,000. A. J. Thomas, 137 East 45th St., New York City, Archt. and Engr.

N. J., Summit — Guilbert & Bettelle, Archts. and Engrs., 2 Lombardy St., Newark, will receive bids about April 28 for a high school including a steam heating system, here, for the Bd. Educ. About $250,000.

N. J., Summit — The Joint Ownership Corp., 7 East 42nd St., New York City, is having plans prepared for an apartment house including a steam heating system, here. About $600,000. H. B. Mann, 70 East 45th St., New York City, Archt. and Engr.

Pa., Belle Vernon — The city has plans prepared for a filtration plant including new pumps, etc. About $50,000. L. Hudson, Wabash Bldg., Pittsburgh, Engr.

Pa., Harrisburg—The Harrisburg Hospital, Front and Mulberry Sts., will soon award the contract for a 4 story and a 6½ story hospital addition on Front St. About $750,000. E. F. Stevens, 9 Park St., Boston, Mass., Archt.

Pa., Homestead — The School Bd. will soon award the contract for a 3 story school. Seperate bids for installing heating, etc. will be received. About $325,000. A. G. Wickersham, McClure Ave., Archt.

Pa. Johnstown — The Johnstown Theatre Co. will soon award the contract for a 3 story, 82 x 135 ft. theatre on Vine and Franklin Sts. About $500,000. H. J. Krapp, 116 East 16th St., New York City, Archt.

Pa., Philadelphia — The Dept. of City Transit, 1211 Chestnut St., will receive bids until April 26 for two 2,000 k.w. rotary converters and transformers for the Fairmount Ave. Sub-Station.

Pa., Pittsburgh—The Oliver Iron & Steel Co., 10th and Muriel Sts., will soon award the contract for a 1 story, 40 x 85 ft. boiler house on Carson St., South Side. Cost between $35,000 and $40,000. W. G. Wilkins Co., Westinghouse Bldg., Archt.

Pa., Tarentum—The city is having plans prepared for a coagulating basin, addition to filtration units and addition to pumping plant. About $40,000. L. Hudson, Wabash Bldg., Pittsburgh, Engr.

Pa., Williamsport—The Y. M. C. A., c/o Mr. Brown, is having plans prepared for a 2 story, 77 x 139 ft. Y. M. C. A. building including a steam heating system. About $500,000. M. E. Kirkpatrick, 130 South 15th St. Archt.

D. C., Washington—The Dist. Comrs. will receive bids until May 2 for furnishing 2 water tube boilers of the Babcock and Wilcox type or equal.

W. Va., Charleston—T. L. Kearse, Strand Theatre is having plans prepared for a 3 story, 94 x 225 ft. theatre and business building including a steam heating system on Summer St. About $300,000. Mills & Millspaugh, 67 East Long St., Columbus, O., Archts.

S. C., Embree—The Edisto River Lumber Co. is in the market for a 350 hp. engine and other equipment for an 8 or 9 ft. band saw mill. D. A. Gardner, Mgr.

Tenn., Nashville—The State Bd. of Administration plans to build a heat and power plant at the Central State Hospital. Legislature appropriated $25,000 for the project.

O., Akron—The Bd. Educ. plans to build a 2 story, 140 x 240 ft. Caldwell school including a furnace and steam blast on Dayton St. About $300,000. M. M. Konarski, 102 South Union St., Archt.

O., Canton — The Bd. Educ. is having plans prepared for a 3 story, 144 x 226 ft. senior high school including a steam heating system on 6th St. and Garfield Ave. About $500,000. W. C. Lane, Clk. G. Hammond, 1220 Prospect Ave., Cleveland, Archt.

O., Kent—The Bd. Educ. will receive bids about May 17 for a 2 story, 160 x 200 ft. high school. About $350,000. H. W. Bomers, Clk. Mills & Millspaugh, 67 East Long St., Columbus, Archts. Noted Nov. 16.

Mich., Detroit—The Water Bd., East Jefferson Ave., received bids for furnishing and constructing mechanical quipment for unloading and handling coal at the waterworks pumping station from the Guarantee Constr. Co., 140 Cedar St., New York City, $61,940, Palmer Bee Co., 2778 East Grand Blvd., $64,077 Link Belt Co., 329 West 39th St., Chicago, $71,829, and for ash handling equipment from Palmer Bee Co., 2778 East Grand Blvd., $10,190, W. E. Wood Co., Ford Bldg., $10,417. Guarantee Constr. Co., 140 Cedar St., New York City, $12,050.

Mich., Muskegon—The Bd. Educ. will receive bids until May 2 for a 2 story junior high school including a steam heating plant on Denmark Ave. and Cleveland St. About $300,000. H. H. Turner, 923 Michigan Trust Bldg., Grand Rapids, Archt. Noted Sept. 28.

Mich., Niles—The Bd. Educ. had plans prepared for a 3 story, 218 x 230 ft. school including a steam heating system. About $400,000. Perkins Fellows & Hamilton, 814 Tower Court, Chicago, Ill., Archts.

Ill., Alton—St. Joseph's Hospital Assn. is having plans prepared for a 5 story hospital including a steam heating system. About $300,000. L. Pfeiffenberger & Sons, 102 West 3rd St., Archts.

Ill., Harrisburg—The Bd. Educ. is having plans prepared for a 2 story, 140 x 140 ft. school. About $300,000. G. Davenport, Pres. A. L. Barnes, 1329 Birchwood Ave., Chicago, Archt.

Ill., Peoria — The Bd. Educ. is having plans prepared for a 2 story rear addition to the manual training high school including a boiler room, forge and metal shop, etc. About $225,000. F. L. Klein, 331 Main St., Archt.

Ill., Villa Park—The village plans to install a pump pit with pump, etc. in connection with the proposed sewer system. About $600,000. E. Hancock, 2047 Ogden Ave., Chicago, Engr.

Wis., Two Rivers—The Wisconsin Textile Mfg. Co., c/o G. C. Hirst, Mgr., will soon receive bids for a 1 and 2 story, 60 x 180 ft. plant to manufacture textile supplies on Main St. Power machinery will be installed in same. About $50,000.

Ia., Cedar Rapids—The Sawyer Biscuit Co. plans to build a baking factory including a steam heating system. About $250,000, Reese Hatchitt, Pres.

Minn., South St. Paul (St. Paul P. O.)—The city received bids for deep well and booster pump, plunger type, etc., from J. Hildred Co., 1019 Commerce Bldg., St. Paul, $12,936 and $24,980; Northwestern Electric Equipment Co., 174 East 6th St., St. Paul, $14,200 and $25,863. Bids include pump house, etc. Noted March 22.

Kan., Manhattan—The State Bd. of Control plans to build an agricultural college building to cost $275,000, a home economics building, $125,000 and a veterinary clinic, $100,000, here. R. L. Gamble, 1415 Fillmore St., Topeka, Archt.

Neb., Lincoln—The Bd. Educ. is having plans prepared for a 2 story, 120 x 285 ft. school including a steam heating system on 26th and North Sts. About $400,000. Fiske & McGinnis, Banker Life Bldg., Archts.

Cal., Los Angeles—The All-In-One-Co., 504 Marsh Strong Bldg., is having plans prepared for one 3 story and seven 1 story factory buildings including a 50 x 200 ft. pattern shop, 200 x 200 ft. foundry, etc. on Slauson Ave. and Downey Rd. About $350,000. J. C. Peterson, Sacramento, Archt.

Cal., Los Angeles—The University Club, Consolidated Realty Bldg., is having plans prepared for an 8 story, 65 x 165 ft. club building including a stam heating, refrigeration and cold storage system on Hope St. near 6th Ave. About $400,000. Allison & Allison, 1405 Hibernian Bldg., Archts. E. L. Mayberry, 468 Pacific Electric Bldg., Engr.

Ont., Hamilton—The Bd. Educ. will soon award the contract for a 2 story school including a vacuum steam heating system, electrical motor, etc. on Lottridge St. About $100,000. W. G. Brown, Provident & Loan Bldg., Archt.

Ont., Kingston—The City Council plans to motorize the pumps in the water-works plant. About $40,000. W. W. Sands, City Hall, Clk.

Ont., London—W. M. Gartshore, c/o McClary Mfg. Co. plans to build an ice arena at Queens Park and is in the market for artificial ice plant and all equipment. About $100,000. J. Watt, Watt & Blackwell, Bank of Toronto, Archts.

Ont., Oil Springs—The Town Council D. P. Sisk, passed a by-law to construct a system for lighting and power construction and is in the market for equipment. About $10,000.

Ont., Paisley—The City Council, R. Forrester, will soon have plans prepared for a hydro-electric lighting and power distribution system. About $20,000.

Ont., Sarnia—The City Council plans to build a technical school on Lochiel St. About $570,000.

Ont., Seaforth—The Council has authorized the appointment of an engineer to prepare plans and submit estimates for a water-works extension including new cast iron mains, electric pumps, etc. About $100,000. J. A. Wilson, Clk.

Ont., Toronto—The Seaman Kent Co., 268 Wallace Ave., is in the market for one 1,000 Imp. gal per min. duplex steam pump.

Que., Montreal—The Medical Building, Ltd., will receive bids about May 1 for a 10 story, 40 x 110 ft. building on St. Catharine St., West. About $1,000,000. Ross & MacDonald, 1 Belmont St., Archts.

CONTRACTS AWARDED

Mass., New Bedford — The city has awarded the contract for a 2 story, 153 x 250 ft. school on Brooklawn Ave., here, to J. W. Bishop Co., 109 Foster St., Worcester. About $750,000.

Mass., South Braintree—(Boston P. O.) The Monatiquot Rubber Wks. Co. will build a 1 story rubber factory on Hancock St. About $200,000. Work will be done by day labor.

Mass., Worcester—The R. H. Long Co., Framingham, will build three 6 story factory buildings on Millbrook St. About $2,000,000. Work will be done by day labor. Noted April 5.

Conn., New Haven—Mendel & Freedman, 772 Chapel St., has awarded the contract for a 4 story business building on Chapel St., to the C. W. Murdock Inc., 505 Grand Ave., at $365,000. Bids for installing heating system will be received later. Noted Feb. 15.

N. Y., New Brighton—(Staten Island) The Bd. Educ., 500 Park Ave., New York City, has awarded the contract for an addition to the high school on Hamilton Ave. and St. Marks Pl., to the Werner Disken Co. Inc., New York. About $518,358.

N. Y., New York—(Borough of Manhattan) The Paterno & Son Corp., 239 West 72d St., will build a 15 story, 100 x 100 ft. apartment house including a steam heating system on Riverside Drive and 88th St. About $90,000. Work will be done by day labor.

N. Y., Tonawanda—J. Spaulding & Sons has awarded the contract for a fibre and paper plant to include one 5 story building and seven 1 story buildings, to the Lackawanna Bridge Co., Abby St., Buffalo, at $500,000.

N. J., Newark—The Aetna Realty Co., 738 Broad St., will build a 3 story, 47 x 202 ft. professional office building including a steam heating system at 1019 Broad St. About $300,000. Work will be done by day labor.

N. J., Ventnor—The city has awarded the contract for one 200 hp. steam water tube boiler and an artesian well for the water-works system, to J. L. Sweigart & Co., Lincoln Bldg., Philadelphia, Pa., at $38,350.

Pa., Philadelphia—The Bd. Educ., 19th and Chestnut Sts., has awarded the contract for a 3 story, 78 x 92 ft. school including a steam heating system on 6th St. and Fairmount Ave., to Melody & Sons, 1322 Race St., at $315,993.

W. Va., Charleston—The City Council has awarded the contract for a 4 story, 103 x 170 ft. city hall on Virginia St., to A. G. Higginbotham, Charleston Natl. Bank Bldg. About $450,000.

N. C., Pinehurst—The Mid Pines Club has awarded the contract for a 3 story club house at Knollwood near here, to C. V. York, Raleigh. About $250,000.

Miss., Starkville—The Mississippi A. & M. College has awarded the contract for a 1 story, 60 x 300 ft. mess hall, kitchen and dormitory building including a steam heating system to R. C. Garber, Jackson. About $300,000.

Ky., Dawson Springs — J. A. Wetmore, Supervising Archt., Treasury Dept., Wash. D. C., has awarded the contract for a power house at the Pub. Service Sanitorium here, to the Murch Bros. Constr. Co., Ry. Exch. Bldg., St. Louis, Mo., at $42,000. Noted April 12.

O., Akron—The Bd. Educ. has awarded the contract for installing a heating, ventilating and plumbing system in the proposed 3 story school on Brittain Rd., to C. P. Cahill Co., at $156,000. Noted March 1.

O., Ironton—The City has awarded the contract for the installation of a heating system in the proposed high school at Beechwood Park, to W. H. Conklin Co., 43-45 North 4th St., Columbus, at $70,497. Noted March 9.

Mich., Detroit—The Dept. of Pub. Wks., City Hall, has awarded the contract for a 1 story addition to the sewage pumping station and chimney, to the John Bollin Co., 1259 Book Bldg., $55,400; for coal handling equipment, to the Purcell Stone Co., Penobscot Bldg., $16,900 and for stokers, etc., to the Detroit Stoker Co., 7342 Woodward Ave., $16,099.

Ill., Centralia—The Amer. Rubber Co., 1526 South Wabash St., Chicago, has awarded the contract for a 2 story 70 x 360 ft. rubber factory and a 500 hp. power plant, to the Welch McCarthy Constr. Co., 56 West Washington St., Chicago. About $150,000

Wis., Cedarburg—The Lauterbach Sale Co. has awarded the contract for a 2 story, 59 x 150 ft. garage, etc., including a steam heating system on Washington St., to the Radke Bros., Main St. About $75,000.

Wis., Jefferson—The Jefferson Rubber Co. will build a power house and is in the market for machinery. About $50,000. Work will be done by day labor.

Wis., Manitowoc—A Stock Co., c/o Chamber of Commerce, has awarded the contract for a 4 story hotel, to W. W. Oeflein, 86 Michigan Ave., Milwaukee. About $400,000.

Wis., Milwaukee—The Random Lake Ice Co., Locust St., has awarded the contract for a 1 story, 130 x 140 ft. ice manufacturing plant, to H. Schmitt & Son, 430 Farwell Ave. About $80,000.

Wis., Whitehall—Trempealeau County has awarded the contract for a power house at the asylum, here, to S. J. Lee, Osseo, Wis. at $17,279. Noted March 22.

Ia., Council Bluff—The Pacific Fruit Express Co., 65 Market St., San Francisco, Cal., will build a 1 story, 200 x 300 ft. refrigerating plant, here. About $700,000. Work will be done by day labor.

Minn., Eveleth — The Bd. Educ. has awarded the contract for a 3 story, 128 x 262 ft. school including a steam heating system to J. and W. A. Elliott Co., 906 Lumber Exch. Bldg., Minneapolis, at $332,768.

Minn., Redwood Falls—The city, c/o H. C. Rutter, City Clerk, has awarded the contract for furnishing one 15 k.v.a. and one 20 k.v.a. current transformers and other apparatus to be used in connection with the ornamental lighting system it plans to install, to the Fargo Electric Co., Fargo, N. D., $16,267. Noted March 22.

Kan., Wichita — The Bd. Educ. has awarded the contract for installing a heating and plumbing system in the proposed 3 story, 98 x 247 ft. school to be known as the Theodore Roosevelt school, to the MacMahon Co., 1329 Oak St., Kansas City, Mo. Noted March 29.

Kan., Wichita—S. M. Miller and Associates, 815 Douglass St., has awarded the contract for a 3 story, 140 x 150 ft. theater and office building on 1st and North Laurence Sts., to G. H. Sudhoff. Cost between $400,000 and $500,000.

Mont., Billings—The School Dist. No. 2 has awarded the contract for plumbing and heating system in high school to the Johnson & Davis Plumbing & Heating Co., 427 17th St., Denver, Col., at $25,174, and in a school addition at $9,591.

Mo., St. Louis — The Power Truck & Tractor Co., Beard and Goldsmith Sts., Detroit, Mich., will build a 1 story, 50 x 250 ft. factory on Goodfellow and Wabash Sts., here. About $1,000,000. Work will be done by day labor.

Tex., Dallas—Baylor University, 5th and Speight Sts., Waco, has awarded the contract for a 5 story, 100 x 180 ft. hospital on Junius and College Sts., to the Inge Constr. Co., Southwestern Life Bldg. Contracts for heating and plumbing systems will be sublet. About $50,000.

Okla., Okmulgee—The Commerce Investment Co. has awarded the contract for installing a heating and plumbing system in the proposed 7 story, 50 x 140 ft. office and store building on 7th and Grand Sts., to the O'Connor Co., Muskogee, at $46,351. Noted March 22.

Utah, Brigham City — The city has awarded the contract for furnishing labor and material constructing power house, retaining walls, bridge, intake dam, 10,900 ft. redwood continuous stave pipe and 2,441 ft. steel pressure pipe, to Gray & Murdock, Salt Lake City, $95,387; for water wheel, governors, etc., to the Pelton Water Wheel Co., 19th and Harson Sts., San Francisco, Cal., $24,505; for generators, switchboards, water wheel equipment, etc., to the Westinghouse Electric & Mfg. Co., Walker Bank Bldg., Salt Lake City, $18,194.

Ont., Bridgeburg—The Bridgeburg Coal Co. has awarded the contract for a 500 ton coal handling plant including conveyors, electric motor, etc., to J. B. Nicholson, 36 Toronto St., Toronto. About $15,000.

Ont., Toronto—The Milnes Coal Co., 88 King St., East, has awarded the contract for a coal handling plant including equipment at the foot of Church St., to J. B. Nicholson, Ltd., Excelsior Life Bldg., at $15,000.

Ont., Windsor—The New Windsor Hotel Co., c/o E. L. Gauthier LaBelle Bldg., has awarded the contract for a 10 story, 200 x 225 ft. hotel including a steam heating and ventilating systems, etc. on Quelette St., to Anglin Norcross Ltd., Montreal. About $2,250,000.

Ont., Windsor—The Separate School Bd. has awarded the contract for the installation of a heating system in the proposed 2 story school on Bruce Ave., to J. L. Heureux at $38,000.